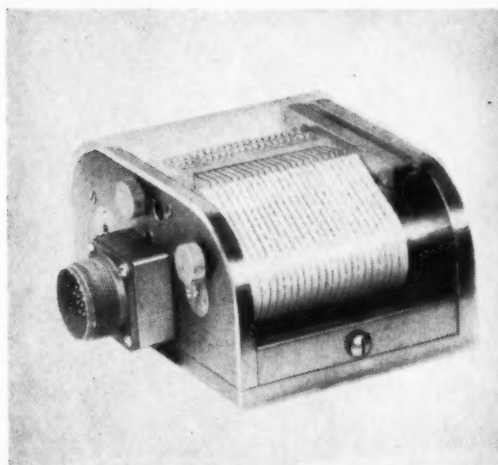


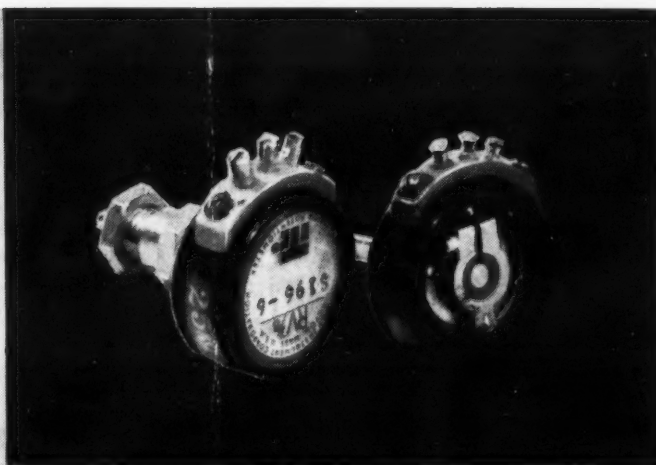
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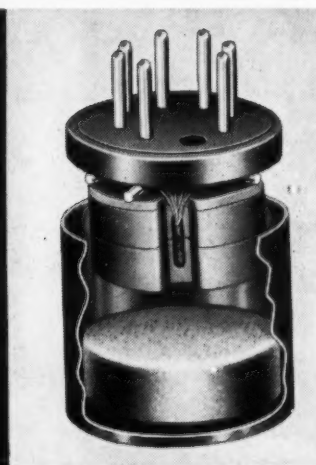
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PRECISION TRIMMER POTS 8

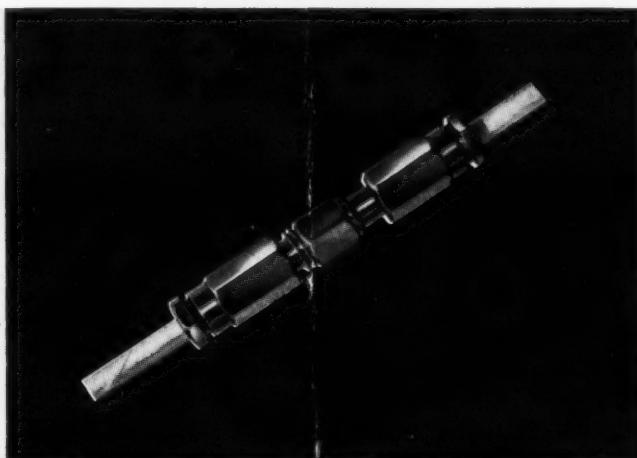
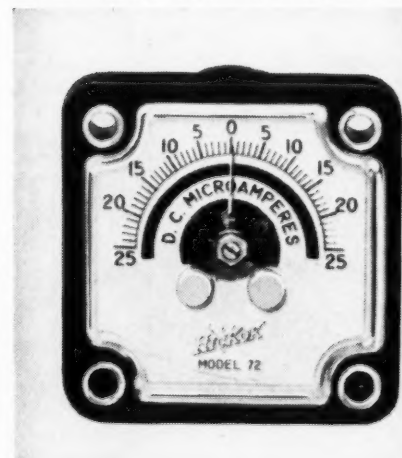


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JANUARY-FEBRUARY
1959

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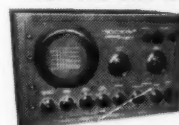
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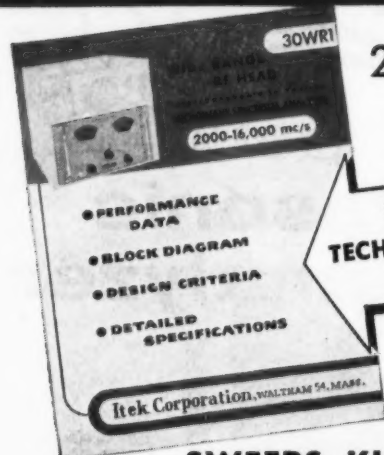
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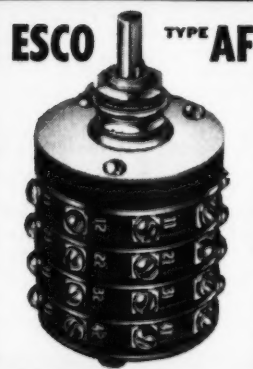
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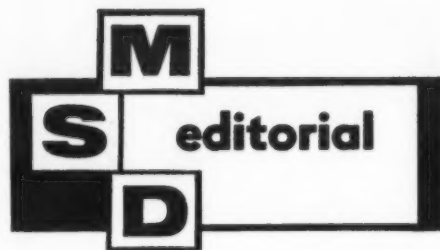
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The Growing Importance of Simulation in Military Training

SIMULATION of combat operations to make military training more realistic, and consequently more efficient, is not a modern innovation but has been used in the training of warriors in every period of history. The use of padded lances in practice jousts, obstacle courses with live ammunition, and mock amphibious maneuvers are alike attempts to simulate actual combat operations which are too dangerous and costly to engage in except under the compulsion of a real war, but which are needed to train and toughen the young fighter so that he may have a chance to survive his first "shot fired in anger."

Feature articles in this issue deal with specific applications of simulation to pilot and aircrew training, and to the simulation of radar scope signals for the training of radar operators and CIC personnel. It is the purpose of these articles to provide some example of servo-electronic techniques used in training-type simulators.

Past issues of **MILITARY AUTOMATION** have provided accounts of the Bell Helicopter Simulator¹, the Air Force Century Series Flight Trainer², and the Celestial Navigational Trainer³. The career of Mr. Ed. Link, the inventor of the Link Trainer which started as a device powered by pneumatic servos but which in its latest versions use electronic and electro-mechanical servo systems, was traced in the July-August 1957 issue.

It is appropriate to note here that Mr. Link was recently elected President of the General Precision Equipment Corporation, parent company to Link Aviation, Inc.

A need for simulated training facilities is seen in connection with the exercising of the far-flung stations of the early-warning networks and the SAGE system. The

¹Helicopter Flight Simulator, Bell Helicopter Corp., Ft. Worth, Tex., p 14 Jan-Feb 1958 **MILITARY AUTOMATION**.

²New Component Advances Reliability of Jet Trainers, Melpar, Inc., Falls Church, Va., p 148 July-August 1958 **MILITARY AUTOMATION**.

³Celestial Navigational Trainer, The Reflectone Corp., p 140, May-June 1958 **MILITARY AUTOMATION**.

only alternative would be to frequently rotate personnel assigned to these stations to central team-training establishments, which would require a considerable outlay in transportation and relief personnel.

It is probable that radar signals generated during mass training maneuvers or actual battle will, in the future, be preserved on magnetic tape for use during training. Techniques similar to those used in the taping of TV programs should provide realistic scope pictures which are seldom realized in training maneuvers with limited numbers of planes or missiles.

Some functions of Nike and other defensive missile firings may be successfully simulated to maintain the skills and confidence gained on the training range where firings at drone targets simulate action against an attacking missile or jet.

Simulation in the Astronautical Age

When military equipment is inexpensive and plentiful, when the environment is familiar and the training situation is not too dangerous, training with actual equipment is likely to be more satisfactory and economical than the use of training simulators. By the same token, flights in new high-performance aircraft, at hitherto untried speeds and accelerations, into out-of-the-world environments, must be undertaken only by men who have received extensive and recent training under simulated conditions. Fortunately, much of this simulation will have already been accomplished as a by-product of simulation necessary to the development process when the new vehicle is completed; be it the X-15 Air-Space plane, or the Orbiting Space Capsule now entering the design stage.

There is every indication that training of military operational personnel through simulation will be increasingly used in the future, and that development of the necessary training devices will be recognized as equally important with the development of the weapon or vehicle, and will be included in the overall system contract package.



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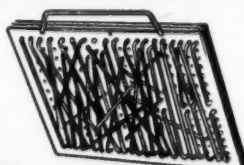
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Lab Radar Simulator Provides Signal-Noise Ratio Accuracy

Lifelike appearance and action of the simulated radar signals, is, of course, essential in any radar simulator used for operator training or other uses. When the simulator is to be used in development work on radar readout devices, however, an exact knowledge of the test conditions, so that they can accurately be reproduced, also becomes essential. The new Model RS-4 Search Radar Simulator, now available for commercial use from the *Federal Scientific Corp.*, 615 W. 131 St., New York 27, N. Y., features the ability accurately to control the signal-to-noise ratio in simulated signals for radar tracking, data processing, and other systems utilizing radar video inputs; enabling testing and development to proceed in any laboratory without using operating radars and actual aircraft.

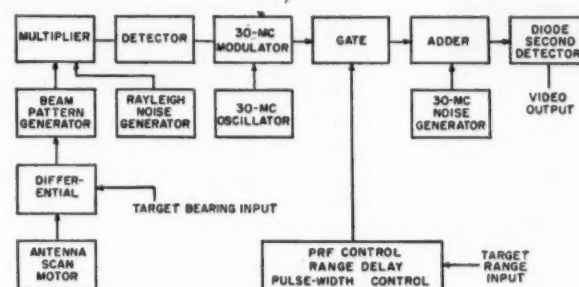


Fig. 1 is a simple block diagram of the simulator and its connection to other equipment. Power required by the equipment is only 20 amp at 115 v, 60 cps.

The developers of the RS-4 point out that in a search radar system the amplitude relationship between signal and noise is complicated by the fact that the signal is usually present in pulse form while the noise is present at all time. Furthermore the signal is, in general, amplitude modulated by the antenna radiation and varies in magnitude because of the scintillation of the airplane as a radar target.

For purposes of analysis in connection with radar data processing, the signal-to-noise ratio is defined as the rms ratio between the signal and noise at the axis of the antenna when both are present. The approximate rms signal value as used here can be obtained by tracking the target for a few minutes so that the antenna axis is always pointed at the aircraft.

If the signal amplitudes are Rayleigh distributed, the rms value of the signal can be computed if the signal dc, or mean, value is known. The following equation gives the necessary relationship:

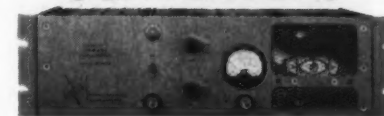
$$V_{rms}/V_{dc} = 2/\sqrt{\pi}$$

By means of measuring apparatus supplied with the simulator, unity signal-to-noise ratio is first established. Insertion of attenuation in the noise channel then permits accurate final signal-to-noise setting.

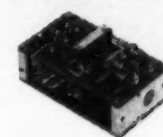
Used in connection with a radar PPI indicator, the simulated signals exhibit lifelike fading, tendency of strong targets to subtend larger angles, and typical noise backgrounds.

For more information circle 61 on inquiry card.

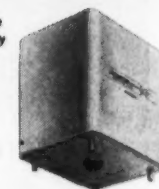
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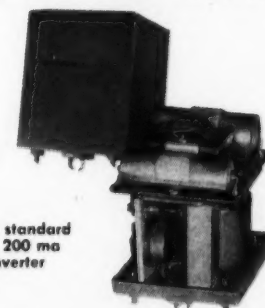
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FIG. 1. CONTROLS AND INSTRUMENTS in the cockpit of the P2V-5 trainer appear and respond like those in the actual aircraft. This Operational Flight Trainer was jointly developed by the ERCO division of AMF Industries, Inc., Riverdale, Md. (Erco Photo)



FIG. 2. STUDENT PERFORMANCE can be evaluated and malfunctions simulated at the instructor's console. WAVE training specialists serve as instructors at many Naval Air Stations. (Erco Photo)

MENTAL AND PHYSICAL demands on pilots and other flight crew members have continually increased with the increasing complexity of modern aircraft. Each man must attain a higher level of individual and team skill than ever before in order to complete the assigned mission. To obtain the necessary training entirely through the use of the aircraft itself is both costly and dangerous. In the Navy training program, many types of specially designed equipments, called training devices, are being used to assist students in attaining the high proficiency required. The Operational Flight Trainers (OFTs) and the Weapon Systems Trainers (WSTs) are two types of training devices that are highly effective and vital tools in this all important training job.

Device 2F21 (Fig. 1&2) which simulates the cockpit of the long range Navy Patrol Bomber, P2V5, is an example of the modern OFTs being developed by the Naval Training Device Center in cooperation with industry. The lift, gravity, thrust, drag, yaw, pitch, and roll characteristics of the specific aircraft are built into an analogue computer which in turn makes the instruments and controls respond in all situations as in the actual aircraft. In addition, all navigational aids and basic communication systems

NAVY FLIGHT TRAINER PROGRAM

CAPT. EDW. C. CALLAHAN, U.S.N.

The Author



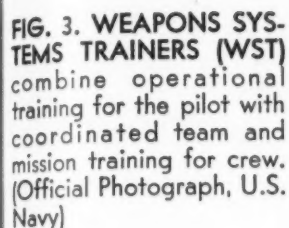
Capt. Edwin Cooper Callahan, USN, Commanding Officer, U. S. Naval Training Device Center, Port Washington, L. I., N. Y., is a Texan who received most of his schooling and engineering training in California schools and Universities. He has also served as assistant director of the Avionics Division, Bu Aer; as director of the Aeronautical Electronics and Electrical Laboratory at NADC, Johnsville, Pa.; and as Electronics Training Officer, Naval Air Technical Training Command. During World War II he was Staff Communications Officer, Task Force 65 (Air), and as Radio Officer on the USS MINNEAPOLIS, for which he received official letters of commendation for action under fire and for his organization of Air Operations Communications at Guadalcanal.

are simulated. Within the cabin of an OFT there is as realistic a cabin environment as is possible within the present state of the simulation art.

The Weapon Systems Trainer (WST), for team and mission training contains two integrated sections, the OFT section and tactics section. All the controls for weapons, communications, and electronic countermeasures are simulated in this type trainer in addition to all flight instruments and controls. The position and equipment used by each member of the flight crew is built into the trainer so that entire missions can be simulated—take off, navigation to patrol area, acquisition of target, attack, ECM and evasive action, navigation to home base, and landing. One such trainer is Device 2F34 (Fig. 3) which simulates the P5M-1 Weapon System.

OFTs and WSTs offer a number of important advantages over operational aircraft in many phases of pilot and crew training and indoctrination. Pertinent points of trainer advantage include:

a. The OFTs and WSTs can be used to train flight crews with little cost and no danger in operations that



Possibly the most obvious value of OFTs lies in their ability to permit training in dangerous emergencies, which is impractical in operational training because of grave possibility of a crash. Such emergencies are associated with a gross unbalance of the plane, wing or propeller ice, or the loss of one or more engines, particularly on takeoff. The saving of one loaded transport by a properly trained pilot—co-

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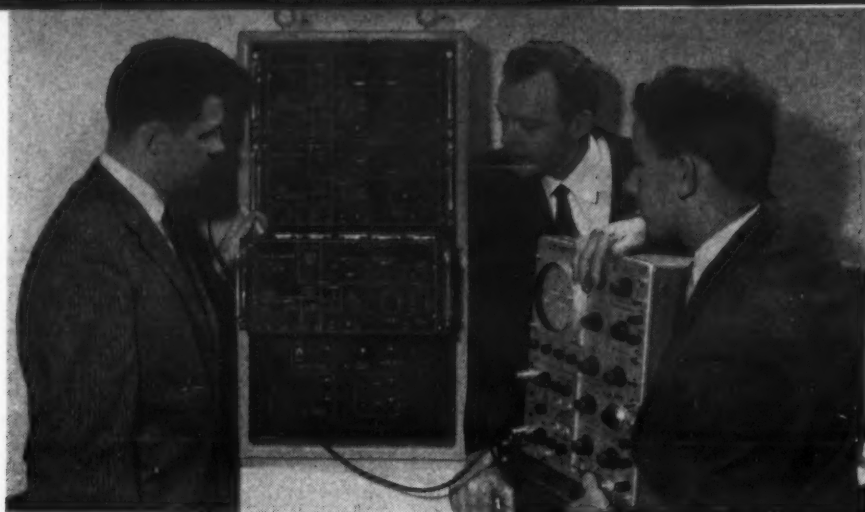


FIG. 1. TRANSISTORIZED Radar Simulator, AN/SPS-T2, has same target capacity as older device shown at right; is adapted to shipboard installation.

FIG. 2. RADAR SIMULATOR 15-J-1-E generated six independent targets controlled in all dimensions and speed, furnished inputs to PPI and RHI indicators.

FIG. 3. NONLINEAR Precision Potentiometer used to simulate electromechanical system functions is modified "in the field" by special tapping kit. (Photo by Technology Inst. Corp., Acton, Mass.)

FIG. 4. FLEXIBLE PHOTOCCELL elements form photosensitive cams having infinite variety of characteristics. (Photo by International Rectifier Corp., El Segundo, Calif.)

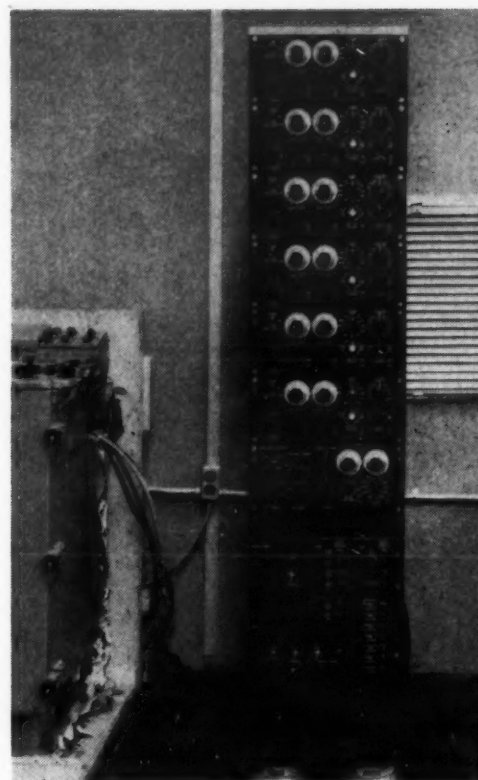


FIG. 2.



FIG. 3.

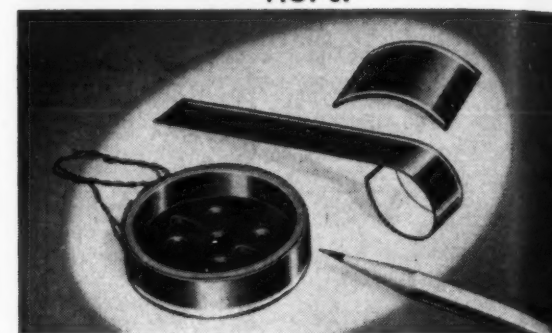


FIG. 4.

Simulator Devices and Techniques Are Varied

EARLY ELECTRONIC training simulators, because of their bulk, high cost and their small numbers, were found only in land-based training centers. This usually made them available only in preliminary training or re-training phases to students who were ordered to the training center for a certain period. These early trainers also lacked much of the realistic similitude now possible with more sophisticated and ingenious devices, and so were of little value for the exercising of experienced personnel.

One result of the trend to miniaturization has been the reduction in size and weight of trainers to the point that operating ships, and even some aircraft, can be equipped with simulators to prevent atrophy of operating skills. This is particularly valuable in the case of radar pickets and antisubmarine warfare units on patrol, in which situation actual targets are difficult or impossible to arrange. Simulated submarine attacks introduced electronically into the CIC equipment of such ships enable "all hands" to keep

their training at peak effectiveness.

Because the motions of the "target submarines" and "friendly forces" are under the control of the instructor, and since the entire action is graphically recorded for later study, such ship-borne ASW trainers provide an opportunity for critical and corrective analysis that is not provided even by actual combat.

An illustration of the type of training device scheduled for use on operational ships is the radar simulator, AN/SPS-T2, (Fig. 1) now being produced by Servonics, Inc., of Alexandria, Va., under a \$2¼ million BuShips contract. This transistorized device is a refined version of the 15-J-1-E (Fig. 2) capable of simulating six targets on both PPI and RHI scopes, each target being separately and completely controllable in all dimensions and speed. Simulated targets are mixed with real video returns and presented directly on operational radar indicators.

The AN/SPS-T2 trainer also presents a digital read-out of target position and speed on its control panel

in both cartesian and polar coordinates. The reduction in size, weight and power requirements which has been accomplished through transistorization is readily appreciated from a comparison of the two equipments. The improvement in the operational readiness of our fleets CIC personnel which should result from the daily availability of such training might well be a decisive factor in a sudden war.

Simulation Techniques

Realistic appearance of radar and sonar targets does not usually rely on synthesis by electronic means alone. Optical, ultrasonic and electro-mechanical devices are freely combined in typical trainers.

The ultrasonic radar terrain simulator utilizes a water-covered scale terrain model of a typical bombing objective. The aircraft search radar is simulated by a rotating ultrasonic transducer which sends out highly-directional pulses through the water, which are reflected and picked up by the same transducer.

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The transducer is moved in three dimensions within the tank to simulate motion of the search radar plane. The ratio between the speed of sound in water and the speed of electromagnetic impulses in space provides the scale of terrain reduction. This device proved valuable during World War II in the training of bomber teams who were preparing to fly missions into unfamiliar territory. It also provided a tactical tool whereby alternate routes and tactics designed to evade enemy search radars could be realistically planned. A new scale model for each change in area is required.

Non-Linear Function Generators

Non-linear relationships between various control functions and simulated responses are necessary in most trainers. These have been electrically simulated by using nonlinear potentiometers having a variety of taps. Such potentiometers are supplied by a number of potentiometer manufacturing, often custom-made to the specifications of the trainer designer. The replacement of these special potentiometers, either as a result of equipment casualty, or because a modification of the response characteristic is desired, is frequently time-consuming and expensive. One manufacturer has provided a "do-it-yourself" jig and computer (Fig. 3) whereby the field engineer can modify stock potentiometers made by that manufacturer to produce a wide range of non-linear characteristics. Another transducer which is readily modified for non-linear functions is the Perkin-Elmer "Vernistat" which was explained in detail in a previous article¹.

Photocells, used with smoked light-wedge cams, have been used in many trainers to simulate fluctuations of signal, random noise, and other non-linear relationships. A new application of the photocell technique is the Contour Photocell (Fig. 4) just announced by the International Rectifier Corp. These specially processed, pliable photocells can be shaped around a cylindrical or spiral form to form a photo-sensitive cam. Readily-modified masks could be used with such cells to provide an infinite variety of non-linear characteristics.

Another fundamental attack on the problem of achieving flexibility of functional characteristics in simulators is by replacing analogue-type computers with digital circuits. Whereas a change in an analog computer sufficient to simulate a second model of airplane would require the replacement of a number of cams or potentiometers, the digital computer would make this modification within a few seconds by the substitution of a second "program tape". It is understood that developments along this line have been undertaken.

¹"New Component Advances Reliability of Jet Trainers," P 148 July-August 1958 MILITARY AUTOMATION.

For more information on AN/SPS-T2 Simulator circle 63 on inquiry card.

For more information on TIC Tapping Kit circle 64 on inquiry card.

For more information on Contour Photocells circle 65 on inquiry card.

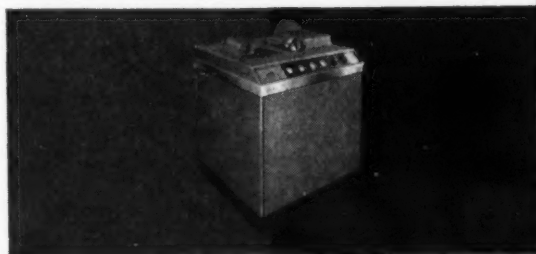
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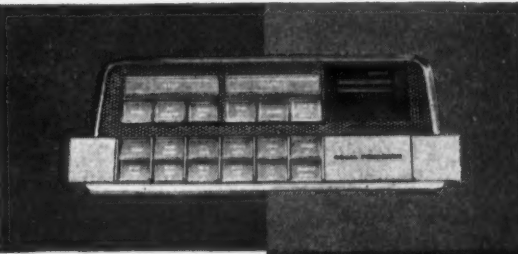
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Precision Trimmer "Pots" in Military Systems

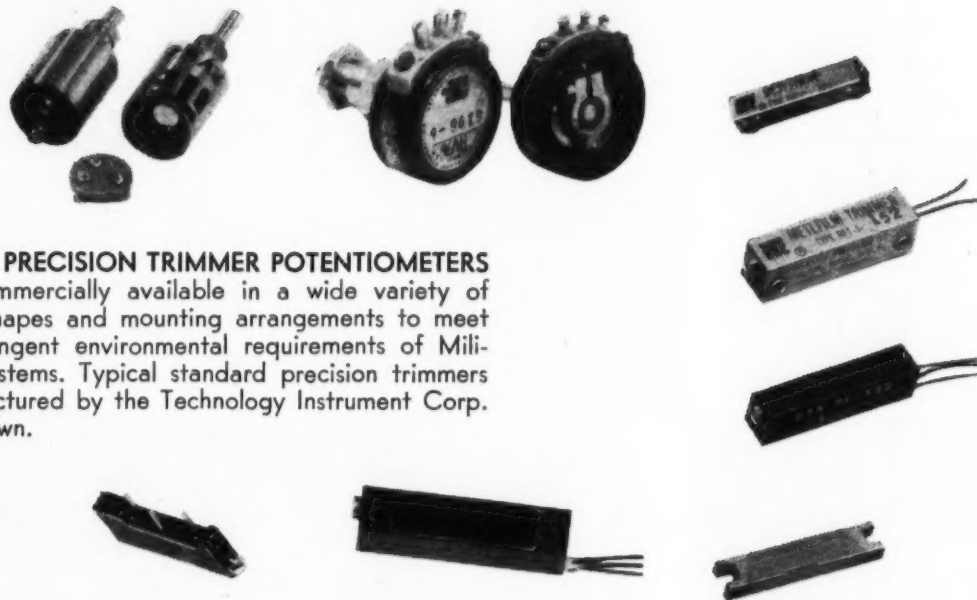


FIG. 1. PRECISION TRIMMER POTENTIOMETERS are commercially available in a wide variety of sizes, shapes and mounting arrangements to meet the stringent environmental requirements of Military Systems. Typical standard precision trimmers manufactured by the Technology Instrument Corp. are shown.

FRED W. ALDRICH, E.E.

Electrical Design Engineer
Technology Instrument Corp.

Trimmer Potentiometers, used in different forms since the beginnings of the electrical industry, today appear as "precision trimmer pots" in military electro-mechanical systems. Under present MIL-specs, the system designer can choose from a wide range of types. This article provides design information to assist him in making his selection and in drawing up trimmer specifications.

TRIMMER "POTS" are used in virtually every electronic equipment manufactured today, and in many systems hundreds of these components are required. Furthermore, in its basic form it has been used in one form or another from the beginnings of the electrical industry.

In recent years, however, a new class of trimmer "pots" has come into being to meet the stringent requirements of military system design. This new class is frequently referred to as "precision trimmer pots." The terminology "precision" here partially stems from the fact that the new trimmers are usually built up from precision machined parts, rather than stampings; also, it indicates the high reliability, stability and overall performance characteristics of the new class. A key feature is that all electrical connections are either soldered or welded.

The precision trimmer "pot" is commercially available in an extraordinarily large range of physical sizes and shapes. (Fig. 1, for example, shows a few standard types provided by a single manufacturer, Technology Instrument Corporation.) This condition has been brought about by two factors. First, the development of the precision trimmer "pot" has been sponsored entirely by private industry. Second, no single MIL-STD specification exists which may be directly applied to the new class. Inevitably, then, different manufacturers came up with physically different designs.

This situation is not without its advantages, however, for it gives the system designer a wide range to choose

from. He is almost certain to be able to find at least one type which suits his application.

Why Precision Trimmer "Pots"?

A trimmer "pot" consists basically of an extended resistance element and a point contact movable along the resistance element. The resistance element may be wire wound, metallic film, deposited carbon, composition carbon or so-called conductive plastic and is usually contained within some form of an enclosure. The point contact may be actuated by a variety of means including translatory shaft motion, rotary shaft motion (either single or multi-turn) or combinations of both.

Basically, trimmers function as calibrating or compensating devices by providing precise control of voltage, current or resistance. They permit the use of looser tolerances in other components which, in turn, affords equipment economy with no sacrifice in precision. In fact, trimmer "pots" frequently permit a higher degree of precision than could otherwise be obtained.

Precision trimmer "pots" are designed to perform their function reliably while being subjected to the adverse environmental conditions imposed by military equipment operation. To achieve maximum stability and reliability, special attention is given to each component part of the precision trimmer. Further, the design provides maximum isolation of the resistance element from the environment in which it must operate.

Precision machined metal parts provide dimensional stability over a wide temperature range, permit the application of higher power due to their heat-dissipating capacity, and provide close mechanical fits for maximum natural sealing. Parts must be plated or otherwise suitably protected to permit unrestricted operation in corrosive atmospheres. Anodized aluminum and non-corrosive stainless steel are the most generally used materials.

Insulating materials must maintain their dielectric strength, insulation resistance and dimensional stability during operation from -55°C to as high as $+225^{\circ}\text{C}$ in some instances. These materials must be either naturally moisture resistant or incorporated into the overall design so as to be little affected by moisture since the entire trimmer may be expected to perform in 95% to 100% relative humidity.

The resistance element itself must be highly stable under the same conditions. Unquestionably, the most stable elements are the wire-wound types using special potentiometer wire with very low electrical noise and a temperature coefficient of under 20ppm/ $^{\circ}\text{C}$.

Precious metals are used extensively in current-carrying portions of the precision trimmer to provide extremely low electrical resistance; to resist the formation of noise-producing oxide coatings at high temperatures, and to maintain stable dimensions. For example, the moving contact is usually Paliney #7, a precious metal alloy. Terminals, if used, are silver plated and then gold flashed.

All these elements of design must be integrated into

the smallest practical package. All openings must be sealed against the entry of foreign particles or moisture. And finally the entire structure must withstand severe vibrations and high impact shocks.

Construction details of a typical precision "half-inch" trimmer are shown in Fig. 2.

Design Considerations for Precision Trimmer

Typical military applications of precision trimmer "pots" include those listed in Table 1, particularly wherever these functions must be reliably performed under extraordinary environmental conditions. The designer must consider carefully the desired electrical, mechanical and environmental requirements of each application when writing his specification for a particular trimmer "pot".

Electrical Characteristics

Total Resistance:

The total resistance required will, of course, depend on the application. Nearly all trimmers offer standard values of resistance between 100 ohms and 20K ohms. From 20K to 100K, the designer must generally choose between wire-wound types and carbon types. Over 100K, the field is dominated by carbon types. There are, of course, some wire-wound types available in the "over 100K" region, but caution is urged in selecting these types since they generally are fabricated with extremely fine resistance wire (wire diameters on the order of 0.0005"). Field reports indicate that mechanical, chemical, and thermal stresses can easily break such fine wire, resulting in open circuit conditions.

Table II lists the practical range of resistance values for some typical trimmer types. However, proven techniques exist for extending this range on either end by permitting certain compromises. For example, lower resistances can be achieved in the wire-wound types with some sacrifice in temperature coefficient through the use of precious metal resistance wire. Similarly, higher resistances can be achieved by deepening the housing to accommodate a larger resistance element.

Total Resistance Tolerance:

Normally, the resistance tolerance of a trimmer is of little importance. No standard tolerance, as such, exists but most manufacturers offers 20%, 10% or 5% as standard tolerance. In some applications, a tighter tolerance may be needed. 1% can be maintained fairly easily in most trimmers at slight additional cost. Below this, however, the cost factor begins to rise quite rapidly. Refer to Table II for standard tolerances.

Linearity:

By its very nature, a trimmer is not expected to be accurately linear. Generally rated at a nominal linearity of 5%, tighter tolerances or non-linear tapers are provided whenever required on special order at some additional cost.

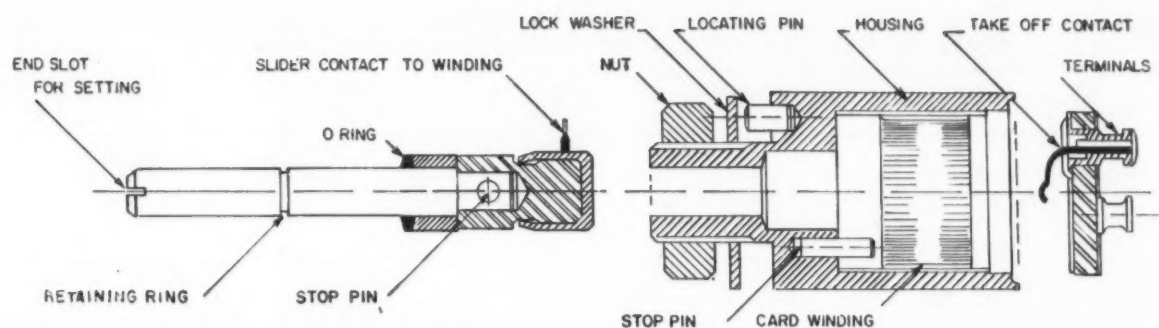


FIG. 2. MINIATURE TRIMMER "POT" construction of typical "half-inch" sealed rotary type trimmer is shown.

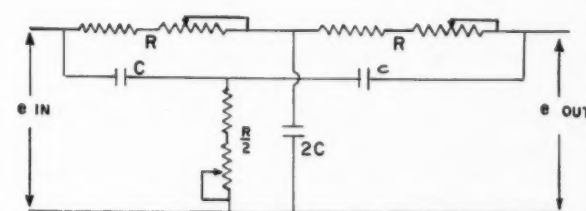
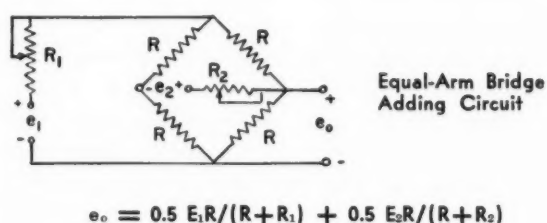
Resolution:

Without question, resolution is one of the most important characteristics of a trimmer. It is of particular interest in wire-wound trimmers where a finite number of wire turns limits the resistance values that may be set. Thus, in a wire-wound trimmer of total resistance R and total number of turns N , the resistance (from slider to one end) will increase in discrete steps of value R/N as the moving contact traverses the element. It is customary to speak of the resolution of such trimmers as $1/N$, or in percent resolution $(100\%)/N$. Resolution improves either with increase

in total resistance (because more turns of smaller diameter wire are needed) or with increase in the length of the resistance element (or the diameter of the housing).

Resistance elements other than wire wound (e.g. metal film, conductive plastic, deposited carbon, composition carbon) offer essentially infinite resolution. Purists, of course, point out that there is really no such things as infinite resolution since, in the final analysis, crystal structure or granularity limit the electrical resolutions, to say nothing of the limitations imposed on the mechanical setability of the wiper.

TABLE 1. TYPICAL TRIMMER POT APPLICATIONS



Gain Control—Negative Feedback

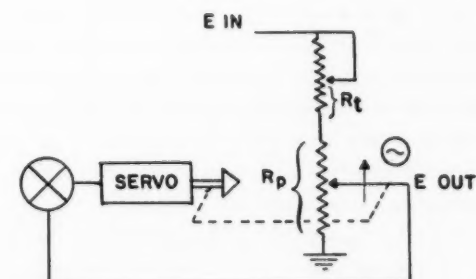
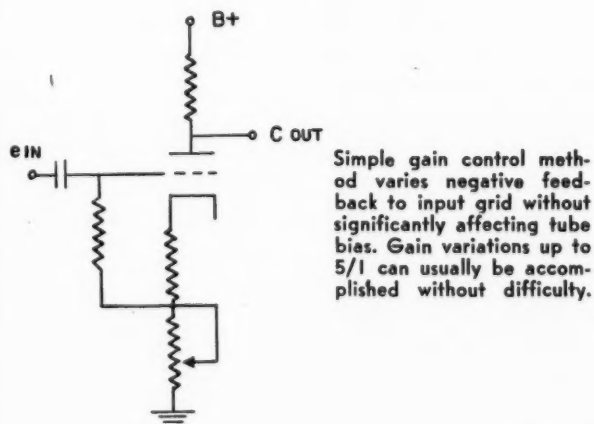
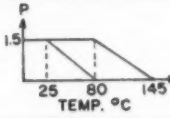
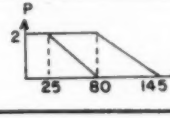
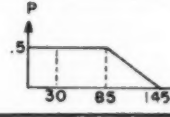
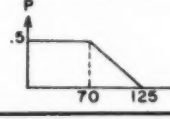
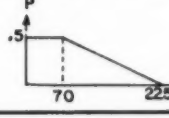


TABLE II. TYPICAL PRECISION TRIMMER CHARACTERISTICS

TYPE	BRIEF DESC.	RESISTANCE RANGE (OHMS)	TEMPERATURE RANGES (°C)	TEMPERATURE COEFF.	CONSERVATIVE POWER RATING (WATTS)
RV05	Wirewound Rotary-single turn 1/2" dia. Bushing mount Internal stops	50-50K ± 10%	-55 to +80 or -55 to +145	0.002%/°C	
RV09	Wirewound Rotary-single turn 3/8" dia. Bushing mount Internal stops	100-100K ± 5%	-55 to +80 or -55 to +145	0.002%/°C	
TP05	Wirewound Rotary-single turn 1/2" dia. Bushing mount Hi torque No stops	50-50K ± 10%	-55 to +80 or -55 to +145	0.002%/°C	SAME AS RV05
RWT	Wirewound Box type 25-turn lead screw Internal stops Metal case Leads	50-25K ± 10%	-55 to +85 or -55 to +145	0.002%/°C	
RFT	Metal-film Box type 25-turn lead screw Internal stops Metal case Leads	50-25K ± 10%	-55 to +125	0.04%/°C MAX.	
RTW	Wirewound Box type 25-turn lead screw Internal stops Plastic case Leads, lugs, or printed CK7 legs	50-100K ± 10%	-55 to +225	0.004%/°C	

Such arguments are academic, however, since in all cases of practical interest the resolution may be considered to be infinite in non-wire-wound trimmers. The maximum resolution error can be computed for each application of a wire wound trimmer as approximately equivalent to $K/2N$, where K is the ratio R_t/R_p and N is total number of turns of resistance wire on the trimmer (Fig. 3).

Temperature coefficient:

All resistive materials are temperature dependent. This dependency is expressed by the *temperature coefficient of resistivity*. Table II shows the wire wound types to be the most stable in this regard with their temperature coefficient of 20 ppm/°C.

This variation of resistance with ambient temperature can cause drifting in applications where the temperature coefficients of the potentiometer and the trimmer are not perfectly matched. The circuit designer will generally be required to estimate the extent to which drifting will occur.

¹Drift due to differential temperature coefficient (α) can be shown to equal approx. $\alpha \Delta T n K / N$ where $\alpha = \alpha_p - \alpha_t$ (Fig. 3) and n/N is the portion of trimmer resistance in circuit.

Power:

Although their power ratings are generally adequate, a precision trimmer is not normally considered

¹Ref: "Selecting a Precision Trimmer" by Frank Bradley, Consultant, The Ahrendt Instrument Co., in Control Engineering, July, 1955.

to be a power device. Depending on its construction, a precision trimmer may be rated anywhere from 1/4 watt up to 6 watts. Metal housing types are used in the higher ranges, being better able to conduct heat away from the winding and dissipate it into the surrounding atmosphere than the small plastic types.

The designer should carefully check under what conditions this power rating is to apply. Most manufacturers follow the JAN-R-19 procedure for arriving at the nominal power rating. Under this method the trimmer is mounted on a metal plate of specified dimension and suspended in still air at 25°C. Power is then applied to raise the internal temperature just to its safe operating limit, (e.g. 80°C). A measurement is made of this power (e.g. 6 watts). The potentiometer is then rated conservatively at only 2 watts at 25°C to account for more typical mounting schemes. Derating for higher temperatures is then taken to be linear (e.g. from 2 watts @ 25°C to 0 watts at 80°C). See Table II for typical power ratings.

It should be clearly understood that these power ratings apply only when the power is being dissipated by the entire resistance element. If only a portion of the element is carrying current, then the heat dissipating area is reduced and the power rating should also be reduced. Typical derating characteristics are shown in Fig. 4.

Phase Shift:

Wire wound trimmers begin to introduce measurable phase shift at 10KC. The degree of phase shift

depends on the resistance of the trimmer as well as its construction. It is least significant in the plastic housing types. Metallic film types generally are usable over a much wider range and in some instances have been used out to 1 mc. At the most commonly used frequencies of 60 cps, 400 cps and 1000 cps, phase shift in all trimmer types is negligible, generally less than 0.1°.

Equivalent Noise Resistance:

The most widely accepted standard of "noise" is 140 ohms peak with 1 ma drawn through the slider. As a standard, it is purely arbitrary. However, the sensitivities of different circuits to potentiometer noise vary greatly from circuit to circuit and in fact this value is frequently not known in the design stage. Thus, although the standard is arbitrary, it is at least a point of departure.

"Pot" noise is by and large heavily concentrated in the high frequencies—up to 100 kc and has an rms value on the order of only 10 ohms. In electromechanical applications, such as servos, very little of the pot noise is actually "seen".

The general procedure adopted by circuit designers is to specify the standard 140 ohms in the design stage, subject to change in the breadboard stage, if necessary.

It is significant to point out, however, that in wire-wound and metallic film trimmers, the noise is dynamic in nature. Static noise is negligible. In other words, noise spikes may occur while the wiper is being adjusted, but will cease to exist when the wiper is fixed in position.

Mechanical Characteristics

Overall Size and Shape:

Precision trimmers are generally available in many sizes, shapes, and with a variety of mounting arrangements (Fig. 1) which must be specified by the system designer.

Single Revolution, Rotary Type:

The active resistance element of this type trimmer covers about 300° to 320° of rotation. Beyond this, on either end, are zero-resistance overtravels and then a non-conducting gap. If the wiper is permitted to ride into the gap, undesirable transients may occur in the circuit in which the trimmer is used. Accordingly, the designer should check to see that internal stops are provided in the trimmer. Many, though not all, manufacturers incorporate such stops as a standard feature. One word of caution, however; in some trimmer types, the location of the stops does not permit the wiper to traverse the entire resistance element. Thus

there will be substantial end resistance in these trimmers. If this effect is undesirable, the designer should specify "STOPS ON OVERTRAVEL." Stops in all TIC trimmers are so located as to permit the wiper to traverse the entire resistance element.

Box-Type Trimmers:

In this type of trimmer, there must necessarily be stops located at both ends of the mechanical rotation. The same caution previously indicated applies—namely, the designer should make certain the stops do not interfere with the travel of the wiper over the full resistance element.

Internal stops in TIC box-type trimmers are specially designed to permit the wiper to encompass the full resistance element. The TIC stop mechanism also incorporates a slip clutch with its slip torque set high enough to provide a positive indication that the wiper has completed its travel and yet low enough to prevent damage to the stop itself.

Shaft Locking:

To prevent the wiper from moving once it has been set, a shaft locking device can be provided. These shaft locks (Fig. 5) are standard for the TIC types RV05 and RV09. They prevent the wiper from being moved either accidentally or under shock and vibration.

In applications where the trimmer requires frequent adjusting by the equipment operator, the shaft locking device is too cumbersome. For these applications, TIC has a special HI-TORQUE series of precision trimmers. As their name implies, this series has a built-in torque device to permit positive positioning without the use of an external shaft locking device. The torque in these units is on the order of 4 to 10 oz.-in. They are especially useful for knob controlled panel mounting applications.

Screw-Driver Slot:

Though obviously an elementary requirement, the screw-driver slot is frequently overlooked. Clearly it is a necessity when the trimmer is to be mounted in areas difficult to reach.

Leads and Terminals:

Single-turn rotary trimmers generally are furnished with terminals while the box type trimmers are furnished with leads. However, on special order, nearly any type of terminals including lugs or printed-circuit legs can be furnished to meet the designer's needs.

Environmental Characteristics

Reliable performance under environmental extremes is the principal reason for the emergence of the precision trimmer as a class unto itself. These extremes include humidity, shock, vibration, temper-

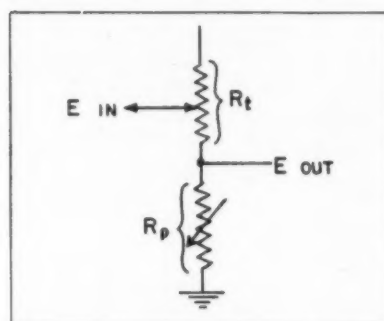


FIG. 3. RESOLUTION of trimmer and drift due to temperature coefficient differential between trimmer and potentiometer must be calculated for each application, as explained in text.

ature, salt spray, sand, dust, explosive atmospheres, etc. Although no single MIL-spec exists on trimmers, most large companies use a composite of tests found in JAN-R-19, MIL-E-5272A and MIL-STD-202.

Humidity:

Perhaps the severest requirement placed on precision trimmers is successful operation under conditions of 95% to 100% relative humidity for extended periods of time. Humidity is natural enemy of a trimmer potentiometer. Its effect is to lower the leakage resistance of the potentiometer which will in turn result in high voltage breakdown. In general, humidity has a deleterious effect on virtually all electrical characteristics of a trimmer unless suitable precautions are taken.

To guard against degradation due to humidity, the exposed parts of the trimmer potentiometer must be constructed of non-hygroscopic materials and it must be thoroughly sealed to prevent to the greatest possible extent the entry of moisture into the potentiometer itself. Close mechanical fits are employed to provide natural sealing. In addition all exposed joints are coated with sealing compounds and "O" rings are used around the shaft. When properly sealed, a precision trimmer will not exhibit any signs of escaping air when immersed in water at 90°C. This sealing also effectively excludes sand and dust.

Salt Spray:

Salt spray is very similar to humidity in its effect on insulation resistance and high-voltage breakdown. It has the further injurious effect of corroding many metals. Accordingly, all exterior surfaces must be suitably protected against corrosion. Stainless steel, if used, must be passivated. Aluminum should be anodized. Brass should be plated. Under conditions of both salt spray and humidity, electrolysis may occur unless guarded against. The higher resistance trimmers are the most susceptible to electrolysis because of the fineness of the resistance wire.

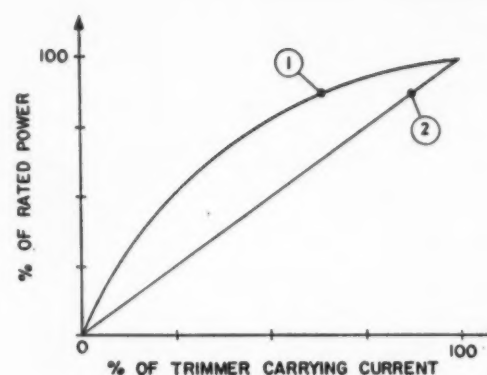


FIG. 4. POWER DERATING curves for trimmers used as variable resistors. Curve 1, for plastic housings; curve 2, for metal housings.

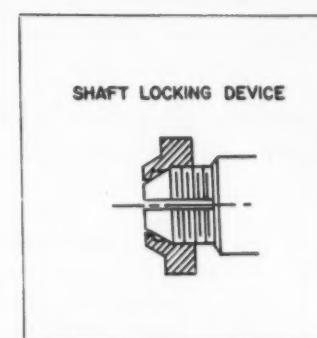


FIG. 5. SHAFT LOCKING device prevents wiper from being moved by accident or high vibration, once it has been set.

Shock and Vibration:

The trimmer may be required to withstand impact shocks up to 100 G and vibrations at 2000 cycles per second with acceleration force of 30 G. To withstand these forces, all non-moving parts of the trimmer must be rigidly secured in place. Moving parts must be made as light as possible and of ductile material so as not to fracture or otherwise permanently deform.

Temperature Tests:

Temperature ranges encountered in military applications are from -55°C to +225°C. Since not all requirements go as high as 225°C, precision trimmers are made available in three temperature ranges; 80°C, 145°C, and 225°C; each range requiring particular attention to insulating materials. Phenolics, for example, will not withstand continuous operation at 225°C.

Temperature cycling will reveal any weaknesses in mechanical design resulting from thermal stresses in the trimmer. Materials of different thermal coefficients of expansion in intimate contact may buckle or fracture under the stress of temperature cycling resulting in a major failure of the trimmer potentiometer.

Rotational Life Expectancy:

A trimmer potentiometer is not normally required to have a long rotational life. Usually, it is set to the desired value and left there until recalibration is required. Thus, the practice has arisen of rating some precision trimmers at only 1000 complete traversals of the resistance element. Unless very fine wire is employed, precision trimmers usually have a life expectancy well in excess of 1000 cycles up to 1,000,000 cycles.

Fungus:

All materials in a precision trimmer must be treated to be non-nutrient to fungus if they are not naturally so.

Additional design data on TIC precision trimmer pots is available on request. Circle 67 on inquiry card.

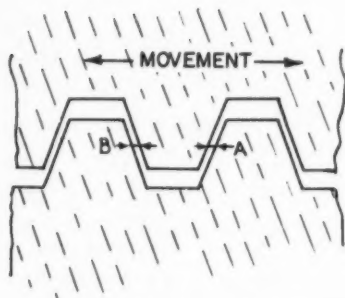


FIG. 1. BACKLASH IN A RACK SYSTEM equals distance "A" plus distance "B".

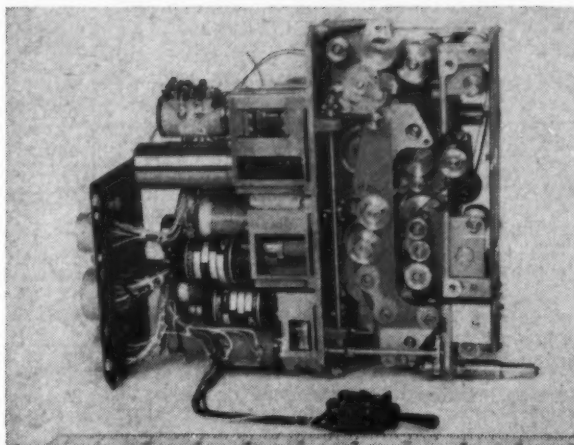


FIG. 2. CAREFUL DESIGN OF PRECISION GEARING avoids troublesome backlash without the use of expensive anti-backlash gears in most applications.

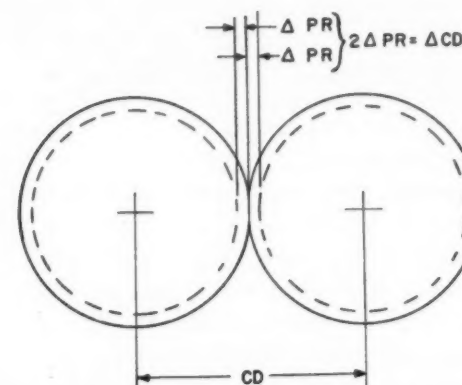


FIG. 3. CENTER DISTANCE manufacturing tolerances, added to other backlash factors, must not exceed maximum permissible backlash.

BACKLASH IN INSTRUMENTATION GEARING

The problem of backlash in instrumentation gearing is frequently dismissed in handbooks and articles on gearing with only a formula and no explanation, or is given an explanation with so many formulas that the designer concerned with a typical instrumentation application is confused. The use of "anti-backlash gearing" is an expensive solution which is sometimes necessary; however, in many gear trains non anti-backlash gears are satisfactory if properly designed.

SOL ZWIRN,

Advance Engineer, Servomechanisms, Inc.,

BACKLASH is the shortest distance along the direction of movement between non-driving tooth surfaces of adjacent teeth in mating gears (Fig. 1). Backlash is very important in instrumentation, as it is the rotational error at any component in the gear train. This error in radians multiplied by the ratio of speeds of the mating gears is the major factor in the angular position accuracy of any instrumentation system.

In feedback instrumentation systems (Fig. 2), backlash can cause difficulty in many areas. Two main difficulties due to backlash are instability in the feedback loop and error between output elements. Instability occurs when there is backlash between the motor and the feedback element, this causes the gear train to have a dead zone where the motor is driving and the feedback element is not moving. When the backlash becomes larger than the electrical dead zone (motor starting voltage) there will be a decided tendency, depending upon inertia, for the system to be constantly hunting for a null position and the feedback loop will be unstable.

Position error can be introduced when there is more than one output element in a feedback loop. Backlash between these output elements will cause the output signals from the elements to be different and thereby introduce an error in the system. Another cause of difficulty due to backlash is in a two-speed feedback loop. When

the multi-turn and single-turn elements have backlash between them a position error results which reduces the nominal effectiveness of the two speed system.

Factors Contributing to Backlash.

The main factors involved in backlash which should be considered in the design of instrumentation gearing are:

1. Change in center distance due to casting and gear plate machining tolerances.
2. Change in pitch radius due to gear manufacture.
3. Shaft eccentricity.
4. Bearing eccentricity.
5. Clearance between bore of gear and shaft.
6. Eccentricity of bore of gear and P.D. (pitch diameter) of gear.
7. Radial play of bearing.
8. Fit of bearing on shaft and in housing.

In instrumentation gearing a condition of backlash greater than zero and less than the maximum allowable at the mesh is the acceptable range for backlash in the mating gears. When there are operating temperature characteristics to be taken into account, proper selection of materials to prevent binding of the gears or excessive backlash is an important consideration. For example, with steel gears of 1" P.D. in an aluminum housing tested with an operating temperature drop of 120°F, interference could be avoided by the use of

bearings with a minimum of 0.00033" radial play for each bearing.

This is derived from:

Coefficient of expansion or contraction of aluminum, $6.5 \times 10^{-6}/^{\circ}\text{F}$; and coefficient of steel, $12 \times 10^{-6}/^{\circ}\text{F}$. Then subtracting, $(12 - 6.5) \times 10^{-6} \times 120^{\circ}\text{F} = 0.00066$ " possible contraction. The same method can also be used for expansion and contraction of other combinations of materials and gear sizes.

Change in center distance due to manufacturing tolerance is the most important factor in backlash; it is the only factor that will not give a change in angular velocity ratio. Change in center distance can be controlled by keeping center distance tolerances at the proper values so that when added to other backlash factors, the sum gives less than the maximum permissible backlash. The second factor in backlash is the change in pitch radius due to gear manufacture, which in turn is translated into change in center distance (Fig. 3).

The other factors involved in backlash can also be translated into change in center distance.

The formula for backlash between two gears is $2 \tan \theta \Delta \text{CD}$, where $\tan \theta$ is the tangent of the pressure angle, (Fig. 4), ΔCD is the change in center distance due to all factors, and the multiplier 2 comes from the complete reversal of direction of gears in a system with backlash (Fig. 1).

In the involute or generated system, because the movement of mating surfaces is normal to the pitch radius and not normal to the involutes of the base circle of the mating gears, the distance traversed in backlash is not exactly the tangent function times $2 \Delta CD$. Also the pressure angle is not a constant because of the separation ΔCD . However, since the tangent function is very close to the actual function and the pressure angle changes minutely because of the change in center distance, the formula $2 \tan \Delta \theta CD$ is acceptable for all instrumentation gearing.

Dimensioning to Reduce Backlash

Change in center distance due to manufacturing tolerances must be minimized by keeping center distance tolerances at the proper values to give less than the maximum permissible backlash. Dimensioning of drawings, to correctly guide the inspection of center distances, is another factor in minimizing change in center-distance.

Referring to Fig. 5, on both gear plates, A and B, the distances X and R are given from banking surfaces to locate hole center No. 1, the starting point for dimensioning the gear centers. In both cases, the gear plates have center distances dimensioned with a nominal center to center distance ± 0.001 " with a ± 0.001 " tolerance. However, on gear plate "A", the center distance between base hole 1 and hole 2; also that between hole 2 and hole 3, is specified. Also the shortest

FIG. 4. LINEAR BACKLASH BETWEEN TWO GEARS equals $2 \tan \theta \Delta C D$; is convertible to output backlash in radians by dividing by the pitch radius and multiplying by the speed ratio between point of backlash and the output shaft.

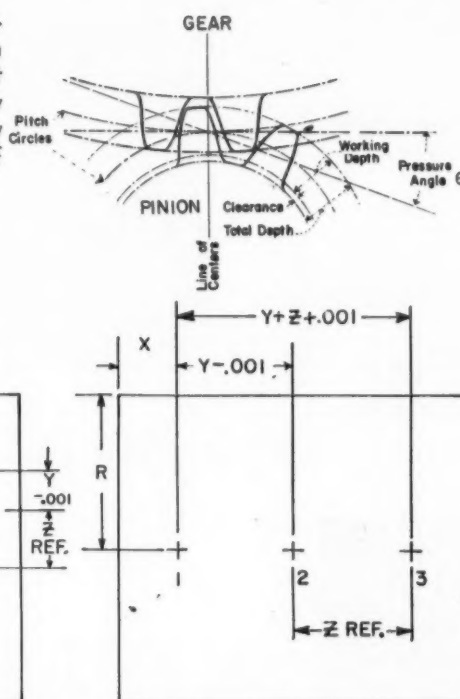


FIG. 5. CONTROL OF TOLERANCES through proper dimensioning.

A. Maximum possible deviation between points 2 and 3 is 0.001". Note center distance tolerances as well as coordinate dimensions are specified.

B. Where coordinate distances only are specified, deviations due to machining error between points 2 and 3 can total 0.002", within the tolerance specified.

coordinate distances from a reference axis through the base hole to the two other hole centers ($Y + Z$ to hole 2, and Y to hole 3) are also given. For gear plate B, dimension Y is given between hole centers 1 and 2, and $Y + Z$ between centers 1 and 3. In this case the dimension R from the horizontal banking surface is used to locate all three holes.

Assuming in each case that the coordinate $Y + Z$ is located with a maximum permissible error of ± 0.001 ", and that the dimension Y is located with the maximum permissible error of -0.001 ", method A will give a maximum possible deviation between hole centers 2 and 3 of only 0.001", while the opposite deviations in method B can cause a total deviation of 0.002" between hole centers 2 and 3.

In summation, the best method of controlling backlash in instrument gears without introducing unwanted ratio error is to hold the pitch radius accurately and vary the center distance where necessary. The formula for computing linear backlash in a gear mesh is twice the tangent of the pressure angle times the change in center distance, due to all causes. Since for small angles (under $0^\circ 40'$) the tangent is equal within five decimal places to the sine, this linear backlash can also be considered as an arc on the pitch radius. This arc, divided by the pitch radius gives backlash in radians; which, when multiplied by the speed ratio between point of backlash and the output, gives backlash at the output shaft in radians.

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*Metavac Resistance Strip used by Naval Research Laboratory on Vanguard Satellite to measure erosion caused by Meteor contact.

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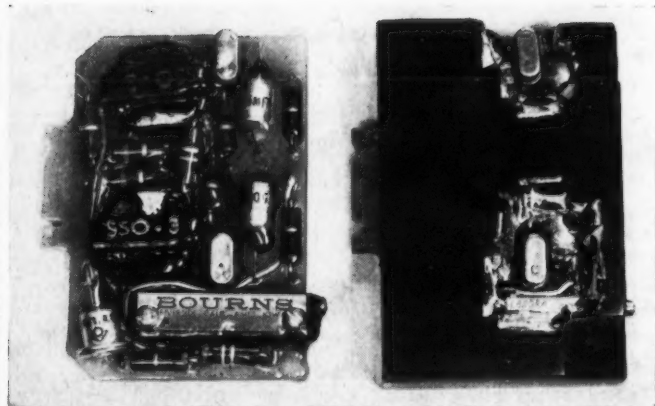
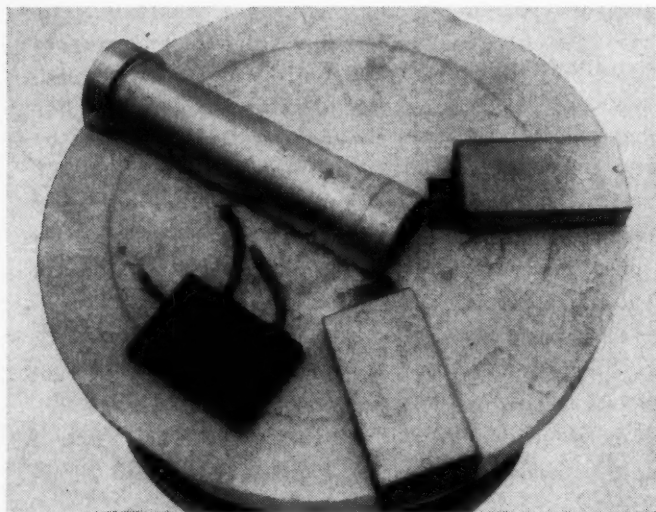


FIG. 1. ASSEMBLED low frequency oscillator unit (left), ready for encapsulation, has been coated with a resilient resin to allow later easy replacement of components. Potted unit (right) shows encapsulating material removed with hammer and chisel for replacement of marginally defective transistors.

FIG. 2. RIGID URETHANE foam shell with soft foam filling protects delicate recording instruments carried in missiles. Besides its tremendous impact absorbing qualities, the urethane foam provides buoyancy needed to keep equipment afloat for hours if it lands in water. (Photo courtesy E.I. DuPont de Nemours & Co.)



EPOXY encapsulation, or "potting", as an effective method to protect electronic circuitry from the effects of vibration, acceleration, humidity, salt spray and other detrimental environments is still an untried technique with many sub-system and component engineers. Other designers, attracted by the method which at first seems deceptively simple, have made unsuccessful attempts to encapsulate circuits or components without first gaining the necessary experience or consulting with experts able to furnish experienced guidance.

However, the benefits of encapsulation are so outstanding that they are worth careful study to determine the proper approach, choice of the molding method, and best selection of epoxy and release agent, so that the many advantages of the method can be realized. These include increased strength and circuit reliability, due to rigid support of all components and leads; stabilization of intra-circuit capacitances; increased insulation strength for high-altitude, high-voltage circuits; and reduction of space requirements. Also potted units, unlike oil-filled cases, do not leak!

Encapsulation has been put to exceptional use by the Rho Engineering Company, Los Angeles, and others; their high voltage power supplies for radar scope operation do not utilize metal cans, and encapsulation prevents internal corona at high altitude. The completely encapsulated units use ROSAN inserts molded in as the mounting provision. Special non-metallic high voltage connectors are used with 30 kilovolt silicone cable. As these connectors are non-metallic the possibility of shock or leakage current to ground under high humidity conditions is next to impossible.

One advantage of encapsulation of equipment is that this method makes it difficult if not impossible for a competitor to determine the circuit or make of components used; yet as will be shown later, the parent

company has little difficulty in repairing encapsulated circuits.

An electronic circuit can either be encapsulated in a metal can or a plastic case; or can be placed in a mold made of metal, glass, or wood and the encapsulating material poured around it. The molded circuit is then removed from the mold, which may be re-used any number of times. The mold method has the advantage that, should a part prove defective it may be dug out and replaced. Fig. 1 shows both an unencapsulated low frequency oscillator (coated with a resilient resin) and an encapsulated unit in which two transistors have been dug out with a hammer and chisel and replaced. In this instance the Beta's of the transistors were marginal and the transistors should have been replaced before encapsulation.

Materials are available to encapsulate anything and to operate in ambients from -60°C to as high as 316°C (600°F). For the best results proper selection of the epoxy to fit the equipment and usage environment must be made; and, in some cases, precoating of the equipment is necessary.

Epoxies can be obtained that are clear (excellent idea for first prototype), gray (for Navy jobs,) black and just about any color you wish. The color, however, can effect the electrical resistivity of the material seriously, depending upon the ambient temperature and permissible leakage resistivity. In general, at temperatures of 71° through 85°F , no significant troubles will occur; but check with your epoxy manufacturer.

Epoxies manufactured to Mil-I-16923B are silica filled—other typical resins are mica and slate filled; foam (lightweight) epoxy is also available. Each has its purpose, and for non-military units a mica fill is usually recommended. Epoxy can also be made resilient by the use of the proper hardener. The resilient epoxy is excellent for low temperature use although its

ELECTRONIC CIRCUITRY



FIG. 3. POLYURETHANE "K-FOAM" packaging (left) reduces cubage required by other cushioning materials by 20%; is also non-hygroscopic, requires only 1/16 as much desiccant in type II packaging.

electrical and mechanical characteristics are not as good as the solid epoxy.

The foam epoxy is excellent where light weight is a necessity but it has the "relative" disadvantage of about one-sixth the dielectric strength of solid epoxy. A urethane foam encapsulation (Fig. 2) is used to protect delicate recording instruments from injury during reentry of Atlas nose cones. Also a polyurethane formulation, designed for packaging of delicate instruments for airborne transportation is compared with other lightweight packaging materials in Fig. 3. Called "K-Foam," it reduces cubage by 20% and requires only 1/16th the amount of desiccant because it is non-hygroscopic, according to the manufacturer, Henry B. Katz Industries, Inc., Newark 4, N. J.

A number of chemical types of foam encapsulating material exist. Typical foam materials are the polyurethanes. These materials are in general more toxic and require different techniques from those used with the solid epoxies. Typical foam weights are 15 to 39 pounds per cubic foot. Foams are available to operate thru temperature ranges of -100°F to about 500°F and may be either flexible or rigid in structure. However, one type of foam which is basically an inorganic encapsulant with physical properties similar to typical ceramics, is available for operation to 1000°F .

In missile applications a relatively long temperature time-delay can be obtained with some epoxies. This feature can be very valuable in missiles with short flight time to avoid malfunctioning by insulating the electronic circuitry from the heating effects of high skin temperatures.

Epoxies are available in single component or two component systems. The two component system utilizes a hardener to be added to the epoxy. Single component epoxy systems offer no mixing problem but do have the drawback that the epoxy and the mold must be heated to a relatively high temperature before pouring.

The exotherm (heat produced by chemical reaction

between epoxy and hardener) will depend upon the epoxy and hardener selected. It can be made as low as room temperature.

Some important steps in using epoxy follow: In selecting the epoxy and hardener, a general purpose epoxy with "slow speed" hardener (low exotherm) will prove satisfactory for most jobs. Circuits utilizing vacuum tubes or delicate parts can first be coated with resilient resin by dipping the circuit board in the resin. After air-drying over night the resin hardens, and the board can be covered with solid epoxy. Using the resilient resin makes it easier to dig out and replace components from a circuit board. This resilient resin is epoxy mixed with a special hardener.

Mixing of the epoxy and hardener must be thoroughly done; this takes some practice or "art". Preferably mix in glass jars, not paper cups. After mixing, it has been our practice to place the epoxy in a vacuum chamber for five to thirty minutes; then to pour the epoxy into the mold. This can be followed by placing the mold in the vacuum chamber, but this is necessary only if very high voltages or exceptional dielectric strength is required. The unit can be air cured, but to obtain the maximum epoxy properties, curing under heat is advisable. Using either heat lamps or an oven set for 175°F to 200°F for two hours is a typical curing schedule; however, it is always advisable to follow the epoxy manufacturer's recommendations.

It is earnestly recommended that interested persons obtain epoxy sample kits which are available from a number of sources and some experimentation be undertaken to gain a first-hand acquaintance with the "art". Also, a qualified expert's services should be obtained before converting a production line to encapsulation.

Acknowledgement: Robert Hudson, Chemical Engineer
Typical sources for materials mentioned:

Epoxy Patch Adhesive Kit, from Houghton Labs., Olean, N. Y. For bulletin 7600-2 circle 68 on inquiry card.

Epocast Trial Encapsulation Kit, from Furane Plastics, 4516 Brazil St., Los Angeles 39, Calif. Circle 69 for literature.

For 4-page folder on K-Foam, Henry B. Katz Industries, Inc., 859 Summer Ave., Newark 4, N. J. Circle 70 for literature.

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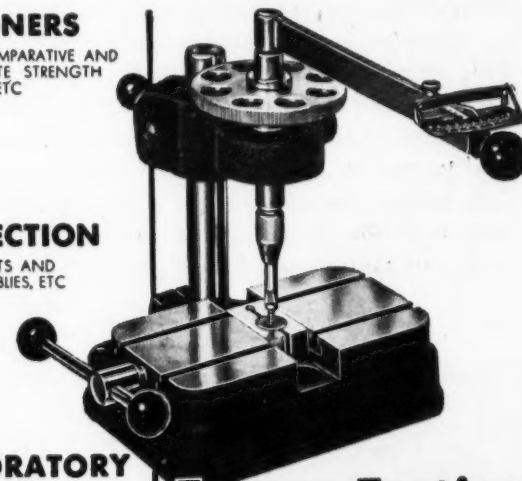
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FIG. 1. THE "SENTRON" GAMMA Radiation Alarm Central Unit serving five sensing stations is designed for continuous operation. Miss Zoe Ferraro holds an enclosed sensing unit which contains its own radiation source for automatic self-testing.

NUCLEAR CRITICALITY is not caused exclusively by planned bomb explosions or reactor operation. The occurrence of accidental criticality at certain activities under the supervision of the Atomic Energy Commission has provided evidence that wherever nuclear fuel materials are handled in quantity, criticality is a possibility. Accordingly, the new AEC regulations promulgated November 11, 1958 have tightened the requirements on radiation warning equipment to be installed in such areas as may be used to store or fabricate nuclear fuel materials.

A leading manufacturer of atomic materials and equipment, who months ago recognized the need for a fool-proof alarm system for his own plant, The Nuclear

Materials and Equipment Corporation, Apollo, Pa., has invented and developed a new radiation alarm system being sold under the trade mark, "Sentron" (Fig. 1). This system not only meets the new AEC requirements but is also outstanding for its many fail-safe features.

Developed for automatic periodic self-testing operation, the new radiation alarm sounds an ear-piercing two-tone Klaxon-type horn whenever ambient gamma radiation exceeds about ten mr/hr. It thereby fulfils the AEC requirement that an alarm be sounded for radiation in the range from five to 20 mr/hr but not sounded for any radiation level below that range.

The heart of the "Sentron" system is an ingenious

device which is referred to as the "Numistor" unit. This unit fulfils the requirement that the alarm system must not be subject to jamming as a result of any saturation which might occur in a G-M tube.

Self-Testing Method is Realistic

The "Sentron" alarm also achieves a high degree of fail-safe operation through a self-testing feature which periodically exposes each sensing element to a critical level of radiation to make certain that its ability to detect radiation is still unimpaired. If any part of the equipment fails to function during this test, or if line power fails at any time, the radiation safety officer is summoned to investigate.

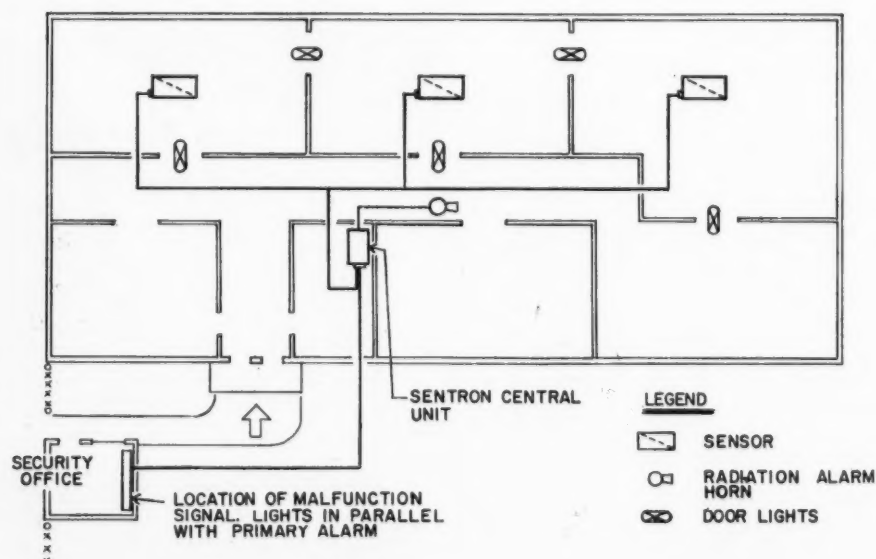
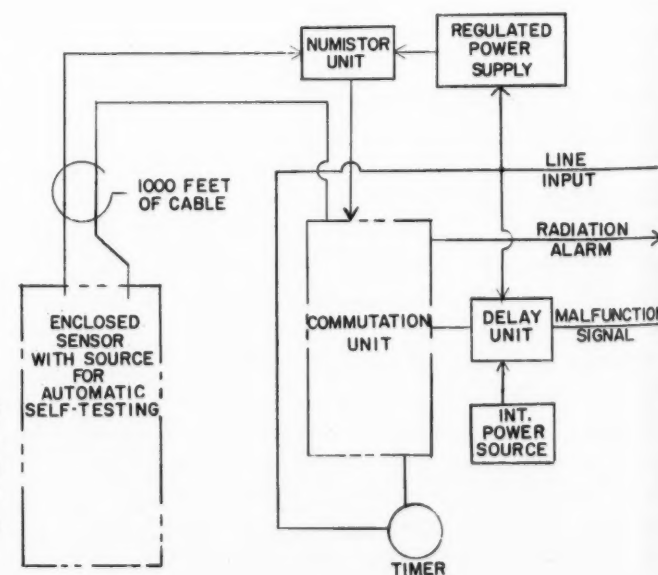


FIG. 2. "SENTRON" ALARM SYSTEM layout. Three sensors and five door lights to indicate contaminated areas are shown. Malfunction or power failure is signalled on board in security office.

FIG. 3. BLOCK DIAGRAM of "SENTRON" Central Unit. Sensors may be located up to 1000 ft. from central unit. Timer determines frequency of malfunction test period.



This test is notable in that actual radioactivity, simulating a criticality accident, is used to test the entire alarm system. The self-testing interval may be set to occur automatically from once every few minutes to only once a day—at the users option.

"Numistor" Unit Makes Alarm Jam-Proof

In the event that a slow, medium or fast rise in radiation occurs in the area surrounding a sensing station, the current in the G-M tube rises above the background level, and the "Numistor" unit sends out a signal through a special circuit.

The details of this clever circuit are not divulged pending patent applications, but provide a criticality alarm signal whether the counting rate barely exceeds a set level or rises to a rate sufficiently high to saturate the G-M tube. The "Numistor" unit provides a conveniently large signal current requiring minimum amplification and having negligible drift.

The destruction of the sensing station would also produce a criticality alarm, while an open circuit would be interpreted as a malfunction at the first system test period.

Alarm System is Widely Adaptable—Ruggedly Reliable

The "Sentron" Alarm system provides for five self-testing sensing stations, (Fig. 2) with capability for any added number operating the same alarm system. AEC regulations require that one sensing station be within 120 feet of any area where criticality might occur. Sensing stations may be located as far as 1000 feet from the console (Fig. 3).

A battery provides standby alarm power for audible and visual failure signals which would respond to either power line failure or a failure in circuitry. Door warning lights are also actuated by the "Sentron" system to direct personnel away from those areas in which high radiation has been detected.

All components have been developed for ruggedness and freedom from adjustments and controls. The "Sentron" system has no "On-Off" switch, because it is intended to operate continuously for years from the moment of its installation. The life of each sensor tube is guaranteed for five years use with backgrounds as high as 1000 counts per minute, except for damage which might be caused by a criticality incident. No sensitive relays or electrometer tubes are used, and all power-type relays in the system are sealed.

A low-cost single-channel alarm system, which does not incorporate the self-testing feature but uses the non-jamming "numistor" circuit, will also be available for applications which may not require all the refinements of the regular "Sentron" system.

The manufacturer also anticipates that the highly reliable "Numistor" circuit will also have extensive applications in alarms for use with nuclear ships, Army Package Power Reactors, nuclear aircraft and in shipyards and airports designed to service nuclear vessels and aircraft.

For more information on the "Sentron" Alarm circle 71 on inquiry card.

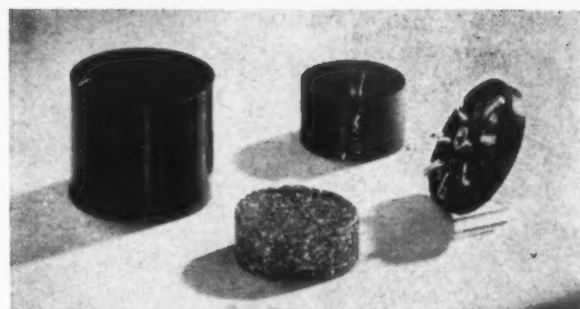


FIG. 1. COMPONENT, shell, epoxy pellet and header assemble into sealed encapsulated unit.

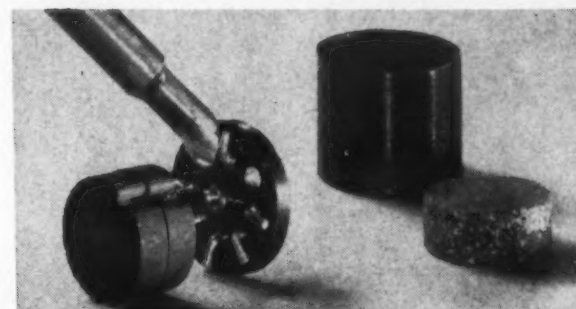


FIG. 2. STEP ONE: Solder component leads to header leads.

Quick 3-Step Method Epoxy Encapsulation

A NEW, all-epoxy encapsulation system that drastically reduces assembly time and reject rates on electronic components, and eliminates costly experimentation on the assembly line is provided in the E-Pak Method developed by Epoxy Products, Inc., 137 Coit St., Irvington, N. J. The method uses an all-epoxy header with embedded lead wires, a cured epoxy shell and a pre-metered epoxy pellet. All three parts of the system may be custom-designed and furnished for particular requirements.

To assemble an "E-Pak" module you only require a component in addition to the three parts of the "E-Pak" just named. In Fig. 1 a magnetic component is ready for encapsulation.

Solder First

To start, the leads on the component or components are soldered to the header leads (Fig. 2). Since this header is made of epoxy which accommodates to a wide range of expansion rates, the metal used for the lead wires is not critical, as with glass headers. The header won't split or crack if too much heat is applied.

Then Assemble

Next comes the assembly process. A pre-metered epoxy pellet is dropped into the cured epoxy shell. Then the header and the component (s) are placed into the shell (Fig. 3).

And Heat

Last, the entire package is placed in an oven and heated. The pellet automatically melts, gels and cures. It flows into, around and over the component, imbedding it and sealing the header. The shell is now hermetically sealed from within to exclude unfriendly environments by a chemically-inert material which also mechanically supports the component, leads and header against damage by shock and vibration (Fig. 4).

Where encapsulation is desired without embedment, a self-sealing epoxy cover is available. "E-Pak" shells, designed for miniature applications, can be obtained in diameters up to about three inches. The system is readily adapted to the automatic manufacturing procedures of most components.

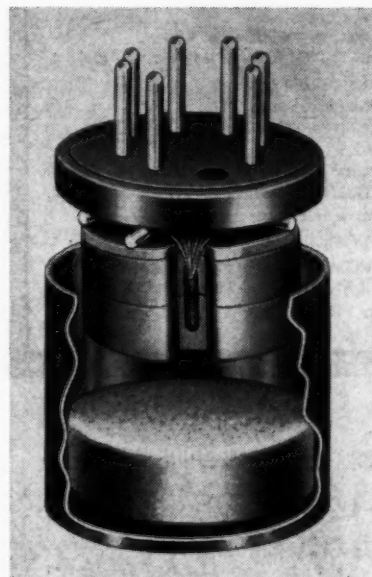


FIG. 3. STEP TWO: Assemble, placing metered epoxy pellet in shell and inserting component and header into shell.

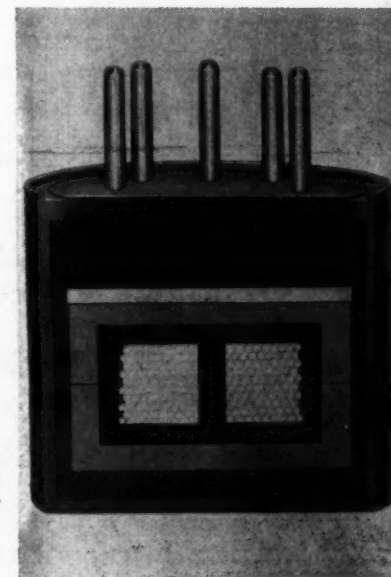
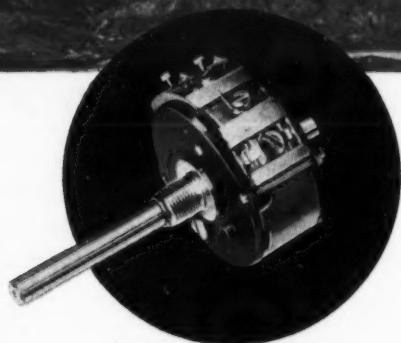


FIG. 4. STEP THREE: Pellet melts, flows into, around and over component, hermetically sealing header to shell.

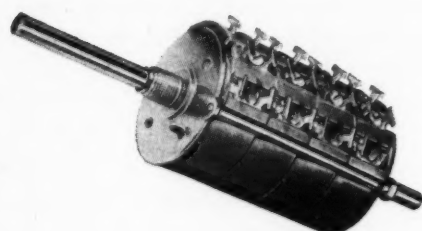
For more information on "E-Pak" encapsulation circle 72 on inquiry card.



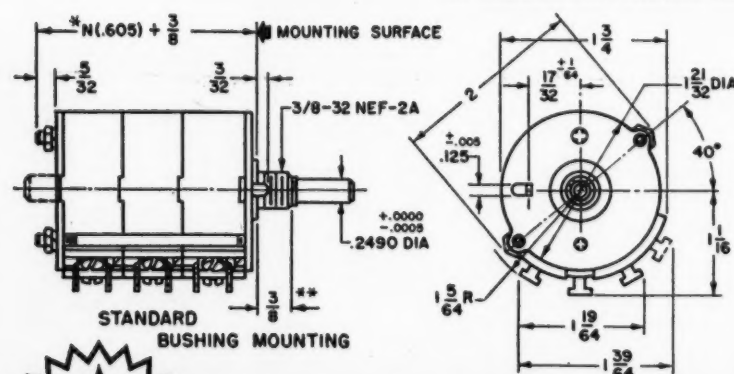
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Solar Research via Stratoscope

SIGNIFICANT and basic solar and astronomical research is being quietly accomplished through the use of gas-filled balloons, which offer a strange contrast to the giant missiles and space vehicles which are the center of today's major news interest. One such project, Stratoscope I, is a cooperative scientific venture under the auspices of the Office of Naval Research and the direction of Dr. Martin Schwarzschild of the Dept. of Astronomy, Princeton University.

The purpose of the Stratoscope flights is to obtain solar telescope pictures with greater clarity and detail than can be afforded by any ground-based telescope, no matter how large, which must shoot through the turbulent and murky atmosphere of the earth. Pictures obtained from the first two flights proved the practicality of this new astronomical technique, giving

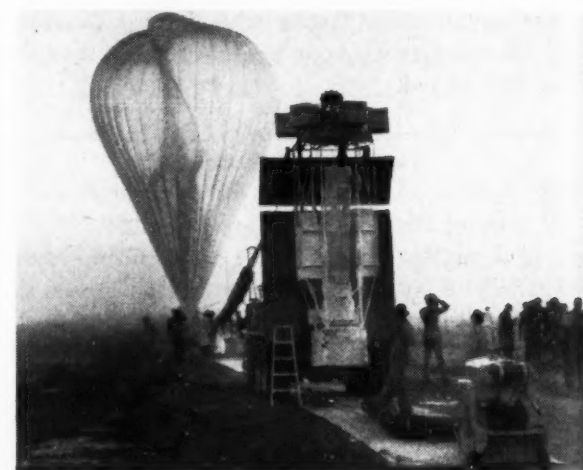


FIG. 1. STRATOSCOPE I BALLOON rises from trailer-mounted launching platform. Stowed telescope is shown on mobile truck-mounted platform in foreground.

sharp images of the "granulated" surface of the sun. "Grains" as small as 150 miles diameter on the sun's surface were distinguished, in comparison with a previously observed minimum diameter of 600 miles. The improved pointing techniques planned for the 1959 flights are expected to increase the percentage of perfect pictures and to enable a succession of photographs to be made of the same location on the sun.

The telescope system used in the 1957 Stratoscope I flights constituted a payload of 1301 lb. Total gross weight of balloon, cargo parachute for recovery, and payload was 2072 lb. To lift this to 80,000 feet altitude required a polyethylene balloon 200 ft long and a diameter of 139 feet. Its volume was 1,092,000 cu ft, and the thickness of its fabric only 0.002". Fig. 1 shows the dynamic method of launching the balloon. A trailer-mounted stationary launching platform is used for the balloon, while the truck-mounted mobile launching platform carries the payload. In this manner, the truck "runs to stay under" the balloon, thus cancelling its horizontal component of rise to pre-

MILITARY SYSTEMS DESIGN

vent dragging of the payload at takeoff. The balloon rises at a rate of 800'/min, reaching its ceiling in approximately one-hundred minutes.

The automatic telescope pointing system, used in 1957 depended on two battery-powered counter rotating clutches on each of two axes. These clutches were controlled by a pair of coarse and a pair of fine photodiode eyes, to locate the sun and hold the telescope pointed at the sun. Although this resulted in a number of perfect exposures, control by a human observer to enable the selection of a particular area of the sun was considered essential for the most effective use of the balloon-supported telescope. Consequently the 1959 version of the Stratoscope I will employ control of the telescope pointing from the ground, using a television link and control system, on which details are not at present available. The Stratoscope I flights are expected to be continued as a tool in solar research.

Stratoscope II, scheduled to fly in 1961, will use a 36" telescope for night photography of planets, etc. Its design study, recently completed by Perkin-Elmer Corp., includes a TV link for remote control and pointing.

For more information on Gen. Mills, Inc., balloons and assoc. services circle 73 on reader's inquiry card.

For more information on Perkin-Elmer Solar Telescope circle 74 on reader inquiry card.

Moldable Carbon-Graphite

Karak Carbon-Graphite is molded under pressures up to 20 T/sq in from a mixture of graphite and other forms of carbon with suitable bonding materials. It is then furnace in temperatures up to 5500°F.

Finished material can be machined to close tolerances, is light in weight with adequate strength; ranging from transverse strength of 3500 psi to more than 14,000 psi. Withstands heat up to 750°F in oxidizing

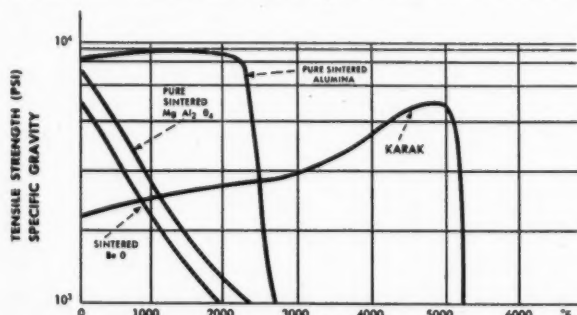


FIG. 1. STRENGTH TO WEIGHT ratios of one grade of KARAK compared to values for other materials, including sintered alumina.

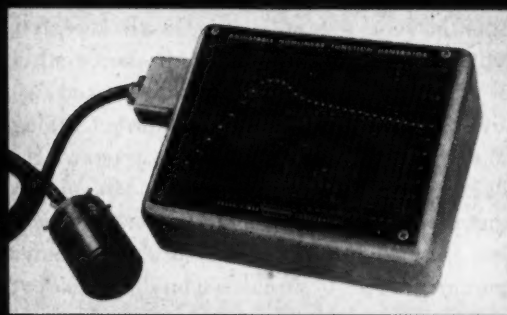
atmosphere; up to 6000°F in controlled atmosphere (Fig. 1). It also has extreme resistance to thermal shock, exceptional resistance to corrosion, is non-magnetic; has good electrical conductivity and arc resistance.

Applications include: Mold assemblies; thrust and annular bearings, including use in acids; nozzles, orifices; plating electrodes; sliding contacts; current collector wheels; oil and grease seals; torque converter seals; pump vanes; steam valve discs; etc.—(From 8-page technical data Sheet, The Ohio Carbon Co., 12508 Berea Rd., Cleveland 11, Ohio).

For this literature circle 75 on inquiry card.

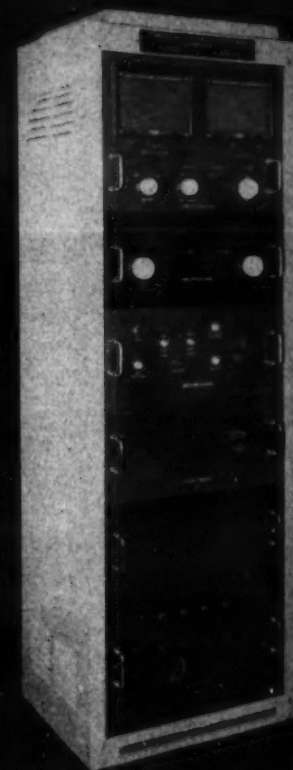
U.S. Army Signal Laboratory designs computer to measure wind effects on missile launchings...

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Near-surface winds at a launching can easily force a missile off course, with the result that the missile lands outside the target area. To counter the effect of such surface winds, the missile launcher is tilted to a corrective angle. Calculating the wind effect and the proper angle of tilt of the launcher, however, can be mathematically quite complex and a time-consuming operation. The United States Army Signal Research and Development Laboratory at Ft. Monmouth, New Jersey has developed a compact computer for this job. Quickly and accurately, from pilot balloon data, the computer calculates both wind displacement on the missile and the proper tilt of the launching stand.



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Linear interpolation between each adjacent pair of the 34 selected volt-

age levels is provided by a Vernistat interpolating potentiometer. Minimum slope of voltage output curve is zero, with a 20-volt maximum between adjacent poles. Maximum output impedance is 130 or 470 ohms. Units are designed for operation over a wide range of frequencies.

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Automation and Control of High Altitude Balloon Flights

JOHN S. BEACH
Brailsford & Co., Inc.
Rye, N. Y.

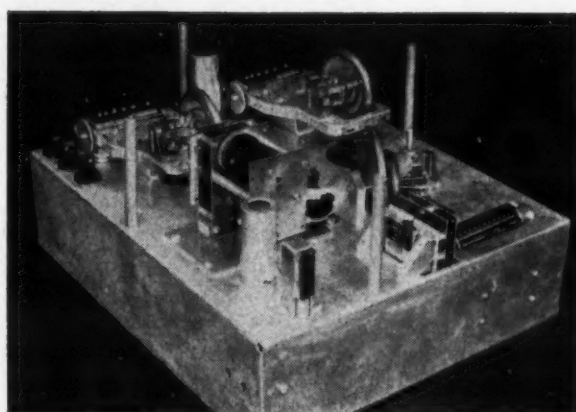
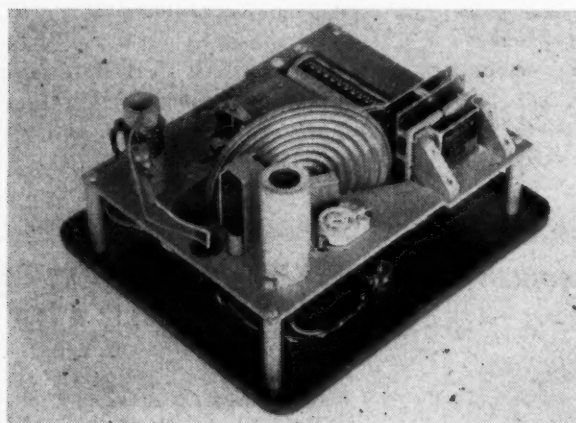


FIG. 1. MASTER CONTROL UNIT automates balloon flight by monitoring altitude, terminating flight if 28,000' flight is not reached in 100 min., performs timing and switching operations during flight, and terminates flight at end of mission. (Photo by General Mills, Inc.)

FIG. 2. BAROMETRIC PRESSURE on aneroid cell positions pickup on code drum to modulate radio transmitter directly in Morse code. (Photo by General Mills, Inc.)



ALTHOUGH the polyethylene "Skyhook" balloon has become a familiar upper air research tool in recent years,¹ no discussion of the automation and control of these flights could be attempted without some discussion of the role of the contract flight services. With the development of this type of balloon with its very high potential payload, it soon became apparent that many of the government agencies, universities and private research foundations engaging in upper air research would be unable to cope with the complexities of preparing, flying and recovering these huge balloons. The contract flight service² offered by General Mills, Inc., Raven Industries, Inc. and Winzen Research, Inc. are an ideal solution to these problems.

The Navy's "Stratolab"; Air Force "Manhigh" flights; the "Stratoscope" camera; Project, "Farside"; rocket launchings and the cosmic ray flights of the Naval Research Laboratories and several universities are some notably successful flights made under this contract system.

In order to automate and control flights for such a wide variety of purposes, extremely versatile control units had to be designed. These units had to monitor balloon altitudes at all times during the flight; to remove balloon and load train from the air should it fail to reach the altitude of 28,000 ft in no more than 100 minutes as prescribed by the Civil Aeronautics Board; perform a number of timing and/or switching operations during the sampling phase of the flight and finally to terminate the flight in order that the instrument package should reach the ground at a relatively predetermined time.

A typical control unit of this type is shown in Fig. 1. The design of the small dc motors in these units is extremely critical in that failure in any way on their part would destroy the usefulness of the flight. These motors and motor driven timers are, therefore, designed for utmost reliability combined with smallest size, weight and power drain. Governed versions of these motors are used in similar applications where a

mechanical or a timing cycle must be maintained in spite of the decreasing battery supply of a prolonged flight.

Because the state-of-the-art of balloon manufacture has reached a very high level, failures on the part of this component are comparatively rare. However, provision must be made in the control unit to terminate the flight should the balloon fail to reach an altitude of 28,000 ft in less than 100 minutes.

This is accomplished through a device which combines a motor-driven timer with an aneroid device similar to the standard radio-sonde baroswitch. This timer may often be conveniently combined with the flight termination switch, as will be mentioned later in this article.

Altitude Monitoring

The success of many flights depends on knowing the altitude of the balloon at any time. This is particularly important in studies relating to cosmic ray count as well as work with ozone or similar atmospheric phenomena. Several pressure telemetering systems lend themselves to this application.

1. *Olland Cycle Modulator*: The familiar Olland Cycle Modulator is an aneroid cell actuated device which keys a radio transmitter at intervals that are a chronometric function of ambient pressure. It is interesting to note that the early radiosonde developed by the Blue Hill Observatory of Harvard University in the middle 1930's employed such a telemetering system.
2. *Code Transmitting Modulator*: In this device an aneroid cell actuated pickup is positioned as a function of barometric pressure on either a code drum as shown in Fig. 2 or on a special phonograph type code disc as used in the AN/AMT-3 Radio-sonde³. While this device does not have the resolution of the Olland Cycle Modulator, it does not require the rather complex recording apparatus required by the Olland Cycle device, as it transmits directly in Morse code.

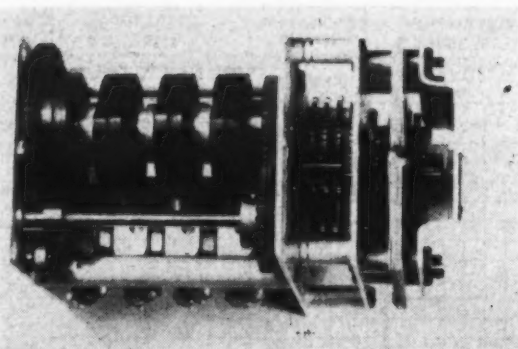


FIG. 3. **TIMER-SWITCH UNIT** combines 100-minute timer, two auxiliary switches and flight termination switch. (Photo by Brailsford & Co., Inc.)

Constant Pressure Level Control

During the latter stages of World War II, Japanese ingenuity sought to develop an unmanned aircraft capable of delivering incendiary bombs to the west coast of the United States. The result of this was the development of what is now known as the constant pressure level balloon⁴; that is, a non-extensible balloon whose control apparatus permits it to maintain flight at a given pressure level, drifting with the prevailing winds incident to that particular level. In the case of the Japanese device, it was a simple oiled silk or treated paper balloon whose instrument or bomb package carried a simple baroswitch which would drop sandbag ballast if the balloon should sink below a certain level and a simple pressure relief valve to prevent a super-pressure of gas from rupturing the bag should its altitude become too great. These simple techniques, combined with the modern technology of plastic balloon manufacture, have produced a balloon assembly capable of remaining aloft at a relatively constant pressure level over a period up to one week.

The most notable *apparatus* of this type is the Transosonde⁵. This device is basically a long range radiosonde measuring the same elements of temperature, pressure and humidity as well as providing wind direction and velocity through being tracked on radio direction finders during the course of its flight.

One of the most successful was the General Mills, Inc. Transosonde Flight #966 of April 24, 1953, being launched in Minneapolis, Minnesota and terminating off the North African coast some four days later. A typical control unit for this type of flight combines the functions of the master control assembly shown in Fig. 1 with a device to release ballast, usually finely powdered steel shot, when the balloon descends below its preset level and a device to valve helium or to pump air into the balloon should it be necessary to decrease its buoyancy. Often a low current dc motor-operated linear actuator, commonly referred to as a ballast integrator, may be combined into the previously described AN/AMT-3 modulator. This motor is in the ballast release circuit and operates the actuator during ballast release to position a pickup previously

used for humidity transmission in the stock unit, thereby giving an indication of the periods of ballast release as well as the amount of ballast remaining in the hopper. The same 100 minute flight termination timer shown in Fig. 3 is ideally suited to constant pressure level flights.

Flight Termination

Although a majority of balloon flights are followed by plane or helicopter, as well as ground crews, a set termination time must be established in order to safely predict the landing area of the balloon as dictated by local weather conditions at the time of launching.

The timer, shown in Fig. 3, is a convenient solution to this problem; combining as it does, the 100 minute timer with two auxiliary switching circuits plus an adjustable flight termination switch. A large phenolic gear, seen at the rear of the timer, rotates at the rate of 1/60 rph and may be manually indexed to any desired position to operate a switch to valve helium from the balloon or to sever the load lines, making the return by parachute. Each tooth is the equivalent of one hour of flight.

If the return is made by parachute, provision will be made from destruction of the balloon; usually by a pyrotechnic device. If the load train is returned to the ground with the balloon after valving sufficient gas to decrease its buoyancy, contact with the ground operates a switch severing all but one of the balloon's load lines. The final line is attached to a rip panel going the height of the balloon. Upon release of the other lines, the balloon, freed from the weight of the train, rises quickly. The restraining rip panel line opens the side of the balloon, causing its rapid deflation.

The "Skyhook" balloon, controlled by these devices, seems destined to have a long life in the field of upper air research, wherever a relatively stable platform is required at a fixed altitude for long periods of time.

Acknowledgment

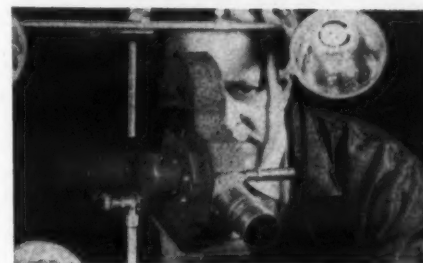
The writer desires to acknowledge the co-operation and assistance of the following persons in the preparation of this article: Charles B. Moore, Jr. and Bernard Vonnegut of Arthur D. Little, Inc.; Thomas Papas, Walter B. Parsons and R. Dungan of General Mills, Inc.; Otto Winzen and M. Lee Lewis of Winzen Research, Inc.; and Duwayne Thon of Raven Industries, Inc.

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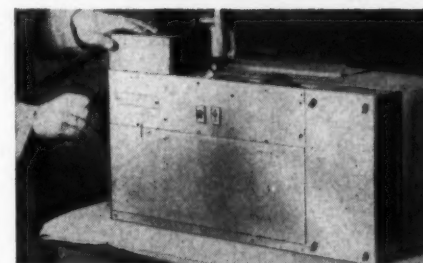
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- (2) "The General Mills Aeronautical Research Laboratories," *Bulletin of American Meteorology Society*. Volume 32-#3 March, 1951.
- (3) Brailsford, H. D.: "A New Code Transmitting Radiosonde," *Journal of Meteorology*. Volume 6- #5 Pgs. 360-362 October, 1949.
- (4) Middleton, W. E. K. and Spilhaus, A. F.: *Meteorological Instruments*, Toronto-University of Toronto Press, 1953, P. 287. See Chapter 10.
- (5) Masterbrook, H. D. and Anderson, A. D.: "The Transosonde," *Weatherwise* Volume 7 -#4 Pgs. 79-81 August, 1954

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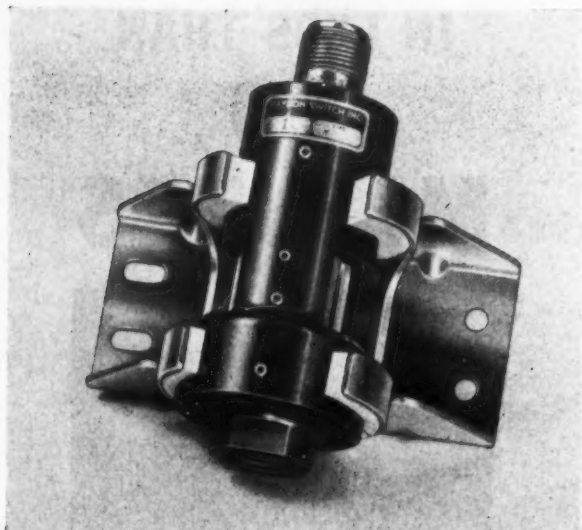


FIG. 1. PRESSURE SWITCH/TRANSDUCER, Haydon 1500 Series, mounted in optional vibration isolator bracket.

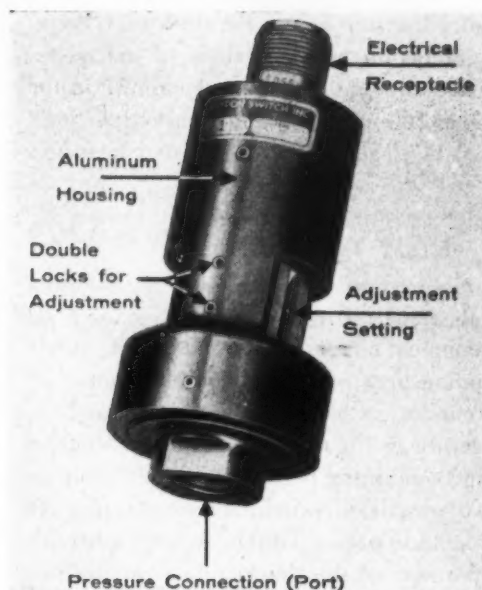


FIG. 2. MODULAR DESIGN of Pressure Switch/Transducer allows interchangeability of sensing elements, loading springs, switches and/or proportional control transducers to cover a wide variety of system requirements.

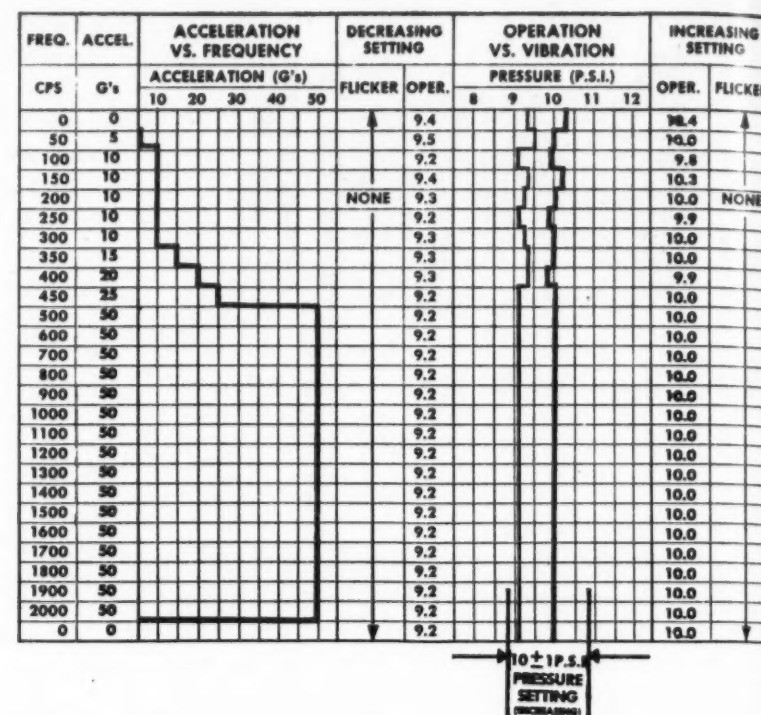


FIG. 3. VIBRATION PERFORMANCE test results, Type 1500 Pressure switch, operation required during vibration within 10 ± 1 psi increasing and within $2\frac{1}{4}$ psi differential on decreasing pressures.

Modular Pressure Switch / Transducer Has Wide Adaptability

PRESSURE-ACTUATED switches and rate signals are required in increasing numbers in new missiles and high performance aircraft. A new Switch/Transducer unit, which incorporates modular pressure sensor, switch, potentiometer, or differential transformer units to form a compact pressure switch or transducer (Fig. 1) has been announced by Haydon Switch, Inc., Waterbury 20, Conn.

Modular Elements Interchangeable

Designed on a modular basis throughout for provision of a wide range of characteristics, sensing elements and springs can be selected to cover eight overlapping ranges in the complete pressure span of 0.5 to 4,000 psi. When used as a pressure switch, the construction incorporates a snap-action switch actuated by movement of a diaphragm or piston. A corrosion-resistant diaphragm is employed for pressure settings up to 800 psi. For higher pressures, a sealed piston is used, permitting all the advantages of the diaphragm at the lower pressures.

Because diaphragms and pistons as well as loading springs are interchangeable in modular increments, a

number of advantages result. Some of these are: Accuracy over a wide temperature range, superior sensitivity to pressure, negligible spring rate or friction, resistance to corrosion, freedom of material selection, and extreme overpressure capacity. The modular interchangeability feature also permits the greatest adaptability to changing service and design conditions, with greatest freedom in selection of materials, and ease of overhaul or disassembly.

Pressure Setting

Exact pressure requirements are met in the selected switch by an external adjustment. The slotted nut in the main housing may be rotated in either direction which, in turn, loads or unloads the main spring and sensing element (Fig. 2). After adjustment to the correct switch actuation point, the nut is securely locked by two set screws. The environmental seal is ensured by O-rings at each end.

Overpressures up to 4,500 psi beyond the pressure setting may be applied to the pressure port without causing drift of the actuation point. A metal-to-metal overtravel stop prevents damage to diaphragm or elec-

trical switch. Also, switch calibration and operation are unaffected by the mounting position. Flexibility of pressure setting and insensitivity to position are not only an advantage in production calibration, but are also very useful in the development and testing of systems at varying pressure levels.

Optional Features

Linear potentiometers and linear variable differential transformers (LVDT) units in various ranges may be substituted for the "on-off" snap-action switch wherever rate signals are preferred to on-off signals. In this case, the range of operation is roughly determined by the choice of loading spring and the piston or diaphragm. The exact positioning of the operating range is then adjusted by the loading of the spring by external adjustment as previously described.

The Haydon 1500 Series Pressure Switch/Transducer in standard form senses gage pressure with reference to ambient air pressure. Barometric, absolute, and differential pressure configurations will also be furnished. Vibration isolation from 200 cps and up can be optionally provided by the molded insert located between the mounting bracket and the switch housing as shown in Fig. 1.

Military Applications

Typical applications for the 1500 Series Pressure Switch/Transducer for aircraft, missiles and ground

support equipment are for control of pressures in inlet air, compressors, combustion air, fuel systems, and engine oil systems. It is also applicable to signal or control depth pressures in submarines or torpedoes. Industrial applications include hydraulic presses, boilers, machine tools, air conditioners, etc. Operating media include aircraft fuels, water-alcohol solutions, hydrogen peroxide, nitric acid, and others.

The switch is qualified under the requirements of MIL-E-5272A for operation or to withstand ambient temperatures from -65° to 250°F , sand and dust, explosions, salt spray, fungus, shock and vibration. Fig. 3 illustrates operating performance of the switch during vibration at up to 2,000 cps at 50 G. Actuation remains well within tolerance limits at all times, with no flicker at any point during this severe vibration test. The switch may be furnished in SPDT, DPDT, or SPST (normally-open or normally closed), rated at 2.5 amps, 30 v inductive load, at 100,000 ft altitude.

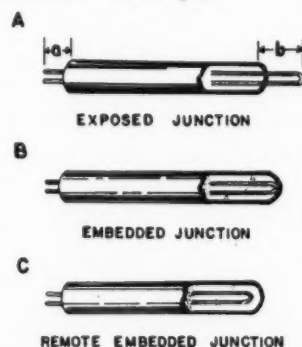
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Metalclad thermocouples, conductors, glowplugs and miniature heating elements for use in jet engines, rocket motors, missiles and atomic reactors are designed for each specific application, using standard Pyrox cables, a product of Pyro Electric, Inc. of Barrington, Ill., for temperatures to 2300°F and over.

Supplied in any length required, with one to four wires, a densely packed insulation surrounded by a solid flexible metal sheath enables Pyrox cables to be installed without additional protection, and to be bent and formed for easy installation. "Hot" ends are supplied to order (Fig. 1), but Pyrox also can be welded in the field using standard techniques.

FIG. 1. "HOT" or Temperature-Sensing Ends. (A) Exposed Welded Junction, insulation is sealed. (B) Embedded Junction is welded into sheath. (C) Remote Embedded Junction is embedded in insulation. Cold ends (a) are stripped 1" and silicone-sealed.



Standard sheath materials are Inconel, Monel and various formulations and types of Stainless Steel but materials such as tantalum, titanium, chrome-iron, nickel, Hastalloy X, and others can be supplied for particular requirements. Standard Pyrox cables are insulated with highest purity magnesium oxide in rock-hard compaction. For special applications a variety of other insulating materials are available, including aluminum oxide and zirconium oxide. For the special requirements of the nuclear field, Pyrox is supplied Boron and Hafnium free. (From 8-page "Pyrox" catalog, Pyro Electric, Inc., Dept. 30, P. O. Box 232, Barrington, Ill.)

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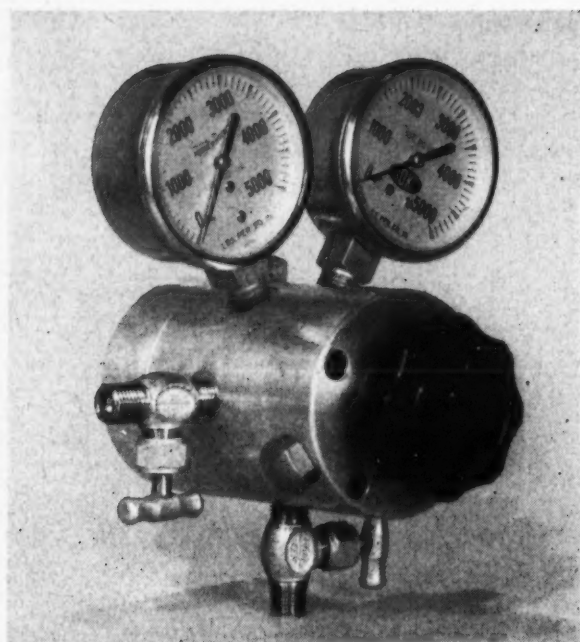
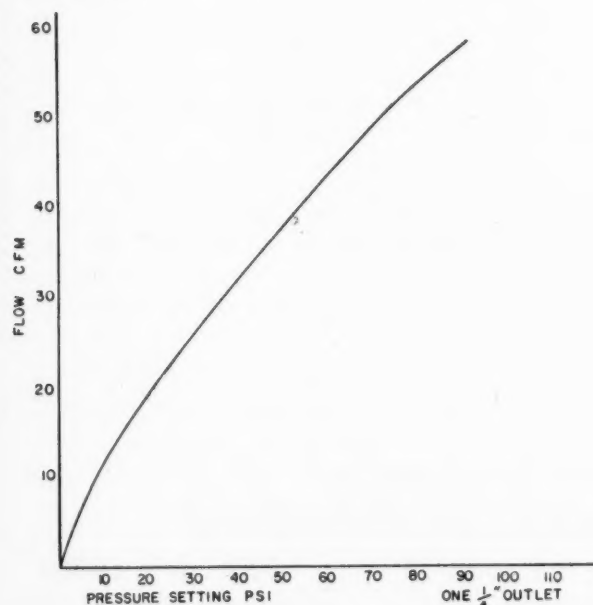


FIG. 1. TYPE 920 REGULATOR for missile and other military applications controls outlet pressures within 2% to any set value in the 1-5000 psi range regardless of fluctuations in supply pressure up to 50%. Designed to Mil-Specs for air and inert gas applications.

FIG. 2. FLOW VS PRESSURE SETTING characteristics of Type 920 Regulator, using single outlet orifice. Two outlet ports are available to increase flow if needed.



DESIGNED to meet the requirements of MIL-C-26037A (USAF) for use with type MC-11 compressors for pressurizing air and inert gases, a new hand-loaded two-stage regulator (Fig. 1) provides regulated delivery pressures from 1 to 5000 psi from inlet pressures to 6000 psi. A 50% change in inlet pressures is said to cause less than 2% variation in set delivery pressure. The valve, named the Hoke Type 920 Regulator, operates over the -40° to 150°F temperature range, and is a development of Hoke, Inc. 33 Pierpont Rd., Cresskill, N. J., leading manufacturer of small precision metering valves.

The superior performance of the new regulator is attributed to (1) a principle of ballast operation, by which the high-pressure gas provides the means for pressure reduction; (2), simple single-knob control; (3) a feedback principle which speeds regulating action; and (4), two pressure reducing stages to keep the delivered pressure constant despite wide variations in inlet pressure. A special feature also allows gas pressure in the main ballast chamber to be reduced by bleeding directly to the atmosphere. This is used when it is desired not to reduce pressure by allowing gas to escape downstream.

Typical flow rates at low delivery pressures using one $\frac{1}{4}$ " outlet are shown in Fig. 2. Specified flow rates are 30 SCFM at 50 psi delivery pressure and 60 SCFM at 100 psi delivery pressure. Two outlet ports are provided in the event that higher delivery rates are required. The new regulator was recently tested by a major rocket engine manufacturer, who evaluated the regulator as having fast response, excellent stability under wide flow and pressure fluctuations, and as being simple in construction.

Loading the High-Pressure Two-Stage Regulator

Referring to Fig. 3., the drawing shows inlet and outlet ports superimposed. These two openings are entirely separate, however. High pressure introduced at the inlet port "A" is permitted to enter first stage cavity "B" thru O-ring seal (1) until such time as the force exerted on the first stage diaphragm due to incoming pressure overcomes the force exerted by the main spring on the opposite side of the diaphragm. This occurs when there is approximately 150 psi in the first stage cavity. Gas from this cavity flows thru port

"C" past speed-control valve "D" to bonnet O-ring seal (2) and also thru port "E" to second stage O-ring seal (3). The speed-control valve meters the flow of gas when the set pressure is being approached, preventing overshoot and ensuring an accurate final pressure.

When the handwheel control is rotated clockwise it opens bonnet O-ring seal (2), gas is introduced into the bonnet cavity and acts upon the second stage diaphragm. When the force due to gas pressure on the bonnet side of the diaphragm exceeds the forces keeping O-ring seal (3) closed, this seal opens allowing gas from port "E" to escape thru ports "F" and "G". Port "F" is the delivery port and port "G" is the "feed-back" port. Gas is introduced to external systems thru port "F" via a needle valve or other suitable device. Gas flows thru port "G" down into the back-cap cavity, below the first-stage diaphragm. The gas introduced into this cavity increases the force on the first-stage diaphragm tending to overcome the forces closing O-ring seal (1). When this seal opens, more gas at higher pressures flows past it, thru ports "C" and "E" to effect higher delivery pressures.

As long as the handwheel remains positioned in a clockwise direction, pressure will continue to increase and would eventually build up as high as the inlet pressure. However, when the delivery pressure has reached the desired value, and the handwheel is released, the delivered pressure will thereafter remain essentially constant at the desired set pressure.

Reducing Set Delivery Pressure

In order to reduce delivery pressure, the handwheel is rotated in a counter-clockwise direction which permits O-ring seal (6) to open, and gas under pressure in the bonnet passes thru orifices "J" and "G" to the delivery side. The outlet valve at this point must be open and gas flowing for the pressure in the bonnet to be reduced. Obviously, as pressure is lowered in the bonnet cavity the forces tending to close O-ring seal (3) exceed the force due to pressure in the bonnet tending to open it, and this O-ring seal shuts off any further flow of gas; the pressure in the delivery cavity then drops. Pressure in the back-cap cavity will drop when delivery pressure is lowered, because it is directly connected to the delivery cavity through port "G."

Compressors

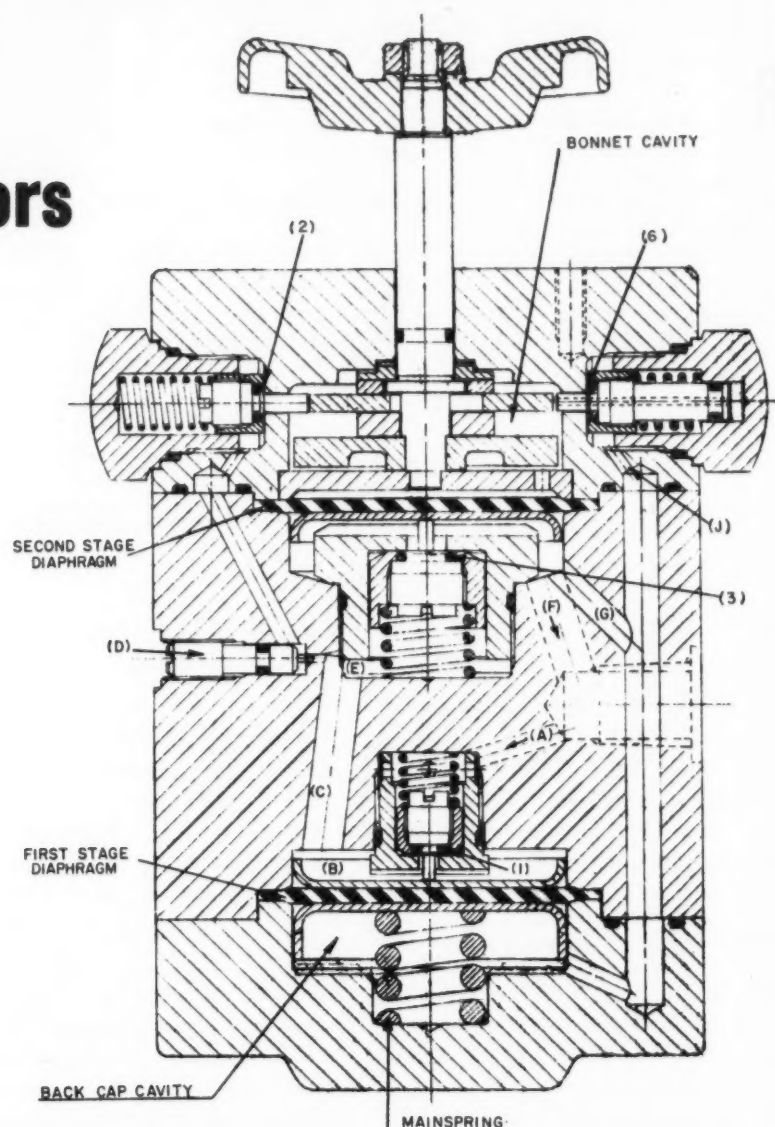


FIG. 3. SECTIONAL VIEW of Type 920 Regulator, showing principle of two-stage feedback regulation which accomplishes fast and accurate output pressure control over wide variations of input pressure.

"Bleed-to-Atmosphere" Reduction of Set Pressure

If it is desired to reset the pressure of the Type 920 Regulator to a lower value when the outlet valve is not open and gas is not being used by the down-stream system, the handwheel is rotated still further in a counter-clockwise direction until a bleed port (not shown in the diagram) is opened to the atmosphere. Pressure from the bonnet and the back-cap cavity is then reduced until the new set pressure is reached.

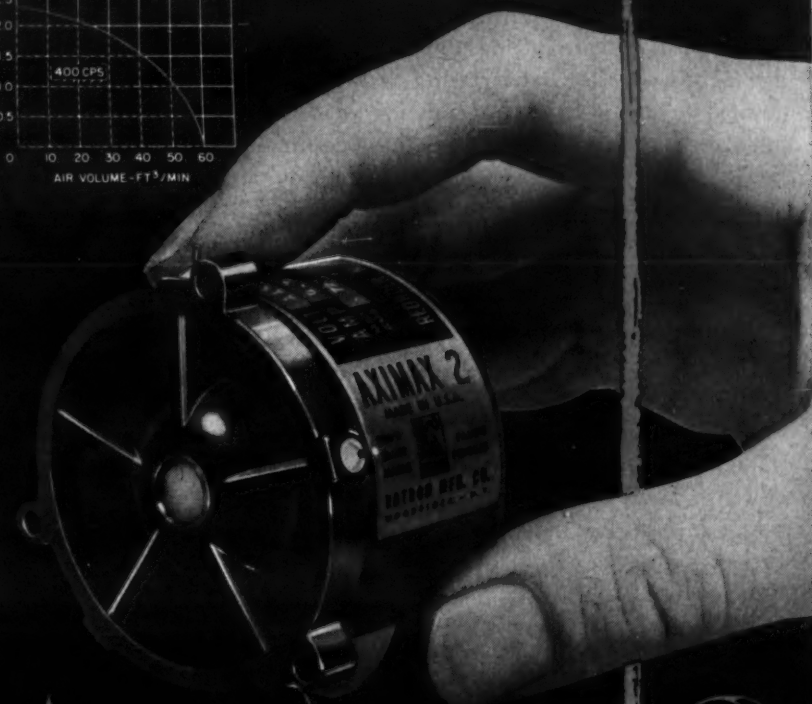
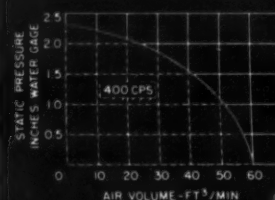
The natural sequence (Fig. 4) of control operations: "Turn clockwise to increase pressure, counter clockwise to reduce pressure," is seen as being particularly valuable in military applications where quick and accurate control of pressures by relatively inexperienced operators may be vital.

For complete characteristics data circle 79 on inquiry card.



FIG. 4. CONTROL INSTRUCTIONS for Type 920 Regulator are straightforward and natural.

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specifications*



Aximax 2

The Aximax 2 vane axial fan is designed for tightly packed "black boxes" aboard aircraft or missiles where maximum cooling is mandatory with a minimum of space and weight loss due to the fan. Air delivery of 60 cfm free air is attained from a fan only 2" in diameter by 1.5" in axial length. Weight is 4.5 ounces.

Variation in driving motors include constant speed 20,000 rpm, 10,000 rpm as well as variable speed Altivar versions. The latter vary their speed inversely with density thereby approaching constant cooling with a minimum of power drain and noise.

Power requirements vary from 400 cps for the standard unit to 1600 cps for special designs. 1 or 3 phase, sinusoidal or square wave. The Aximax 2 meets MIL-E-5400B and other individual missile specifications. Write today for complete technical information to —



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WOODSTOCK, NEW YORK

In Canada: The Hoover Co., Ltd., Hamilton, Ont.

For more information circle 17 on inquiry card.

MISSILE-RIDING EVENT RECORDER

RECORDING OF EVENTS is nowhere more important than during the flight of an experimental missile. Many telemetering channels are usually devoted to the in-flight transmission of data so that this information may guide the development and design of later systems. However, to afford a more complete record, and to provide a permanent record in the event of telemetry casualty, a rugged, miniature event recorder providing an on-off record for each of 21 channels through constant accelerations of 50 G is now available (Fig. 1). It is also applicable in the testing of torpedoes, where telemetering is not practicable.

This recorder, designated the Photron Model 820 G, has been subjected to two-phase shocks in excess of 3000 G for 2 milliseconds, and 300 G for 25 milliseconds. Housed in a rugged aluminum case, it is built to survive impact landings and high shock-accelerations.

The model 820-G recorder uses a chart of electrochemical paper 90 ft long, sufficient to record from 90 seconds to 4 minutes of data at the various chart speeds, accomplished by an easily changed set of gears. It requires battery power of 28 v, 1 amp dc, to operate the governor-controlled chart motor which maintains accurate chart speed despite battery voltage variations. Signals may be applied direct to the stylus if signal voltage is of sufficient strength (6 to 28 v dc). For lower signal levels, each stylus circuit requires a sensitive relay to trigger the stylus voltage (Fig. 2).

The 21 individual styli are mounted in a single

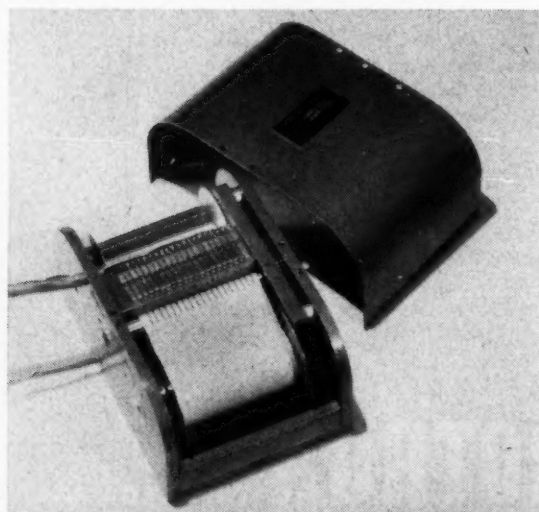


FIG. 1. LIGHT-WEIGHT MODEL 820 G is compact, uses low-voltage electrochemical recording for short-duration flights.

plastic block to conserve weight and space; however, each stylus is individually replaceable. The electrochemical paper does not require developing but should be used within three or four hours after loading because the markings are dependent on the moisture content. It operates over the temperature range of 0° to 90°C, and so is ideal for short periods and short runs such as missile and torpedo work.

Electro-sensitive Paper Recorders

Other Photron event recorders which utilize electro-sensitive (Teledeltos or Timefax) paper charts are also designed for missile use. The model 820 (Fig. 3) provides a standard 21 channels on a 100 ft long, 3 15/32" wide chart. Four speeds, providing running times of from 2 1/2 to 200 minutes, can be selected by changing gears. A stylus voltage of 300 v ac or dc is required for recording on electro-sensitive paper at

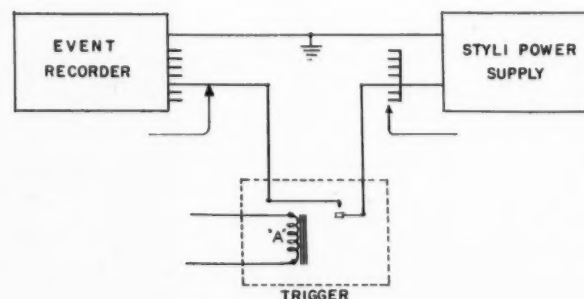


FIG. 2. SENSITIVE RELAY is required for each stylus circuit where signal voltage is less than necessary minimum.

TABLE I. COMPARATIVE CHARACTERISTICS — PHOTRON ON-OFF EVENT RECORDERS

Type	820 G	820	830
Number of channels	21	21	21 (up to 100 on order)
Recording speeds, "/sec	4.5, 6, 7.6, 9.6, 12	1, 2, 4, 8	1, 3, 6, 12
Chart Capacity, ft	90	100	200
Type of chart	Electrochemical	Electrosensitive	Electrosensitive
Stylus current, ma	29	9	9
Stylus voltage	6 to 28 v dc	300 v ac or dc	300 v dc or ac
Motor	Governor-controlled	Governor-controlled	Synchronous
Motor power	28 v, dc, 1 amp	28 v dc, 1 amp	110 v, 60 cps, 5 w.
Recorder Dimensions	3 3/8" x 4 3/4" x 7"	3 1/2" x 5 3/4" x 7"	4 3/4" x 6 1/2" x 10 1/2"
Weight	5 1/2 lbs	6 3/4 lbs	11 1/2 lbs
Power Supply	Not required	Model 21 (4 1/2" x 5" x 7" 11 1/2 lbs)	Model 21 (4 1/2" x 5" x 7" 11 1/2 lbs)
Constant acceleration	50 G	50 G	not rated
Shock acceleration	3000 G for 2 msec 300 G for 25 msec	3000 G for 2 msec 300 G for 25 msec	not rated

normal speeds. At slow chart speeds a lower voltage may be used. However, a separate power supply is required for this type of recording. The Model 820 styli are individually mounted in small plastic blocks and are easily replaceable as single units. The entire styli assembly tilts to allow easy replacement of the chart. Model 820 meets the same operational and shock specifications as the model 820 G.

For applications where a 115-v, 60 cps motor is more readily accommodated and where ability to withstand high gravity shock accelerations is not required, the model 830, which has the same configuration as the model 820, permits higher chart speeds and can be expanded at time of manufacture to accommodate up to 100 channels. Styli assembly and tilting arrangements are identical with those of Model 820. Chart length capacity of 200 feet is double that of the 820 or 820 G models. The 830 model also incorporates a vacuum manifold directly back of the styli to remove the fumes

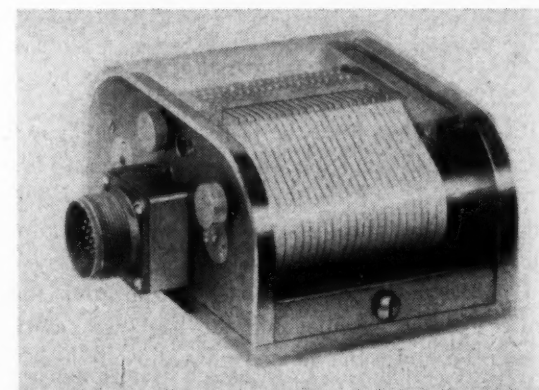


FIG. 3. ELECTROSENSITIVE RECORDING principle which burns signal track into chart surface is used in Model 820 (missile type, shock resistant) and Model 830 (for aircraft and ground bases). Both have external appearance shown here, but Model 830 can be furnished with wider chart, up to 100 styli.



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and soot which are caused by the electric burning of the chart paper, and which is characteristic of all electro-sensitive charts. This model is recommended for airborne, laboratory or time operational sequence recording.

Characteristics of the three Military type recorders are provided in Table I. The Photron Event Recorders are a development of the Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio, who also supply patchboards and trigger systems designed for specific applications requirements. All models of events recorders and accessories will be furnished to Mil-specs on request.

For more information on recorder Model 820-G circle 80 on inquiry card.
For more information on Models 820 and 830 circle 81 on inquiry card.

Optical Level Indicator

Application: The Revere Optical Level Indicator, which contains no moving parts or relays, incorporates a new principle for providing extremely accurate, fast and reliable indication and control of liquid level. Designed for use in water-alcohol mixtures, aviation gas, jet and hydrocarbon fuels, and hydraulic and lubrication oils, these units apply electrical power to indicator lamps, valves, pumps and other electrical equipment when the liquid reaches a predetermined operating level.

All moving parts in the Revere Optical Level Indicator have been eliminated through the use of a transistorized circuit and a photoelectric device to sense liquid level. Models are available for operation on either ascending or descending liquid.

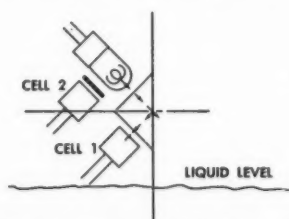


FIG. 1. DRY PRISM reflects internal light.

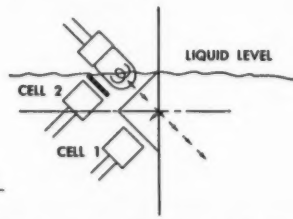


FIG. 2. WET PRISM does not reflect internal light ray.

Operation: The detection of liquid level is based on the principle of total internal reflection. In the "dry" condition (Fig. 1), the light rays strike the plane between the prism and the surrounding air and are reflected onto the sensitive surface of photocell #1. In the "wet" condition (Fig. 2), the light rays are not reflected, changing the resistance of photocell #1.

Two photocells are used in the probe. A filter between the lamp and photocell #2 adjusts the light intensity so that the resistances of the two cells are approximately equal in the "dry" condition. This balanced design eliminates the effects of temperature and voltage changes on the system.

Because the operation of the unit does not depend upon the light rays passing through the liquid to reach the photocell surface, the unit is not affected by contamination, coloring, or transparency of the liquid.—(From 4-page Engineering Bulletin No. 1065, Revere Corp. of America, Wallingford, Conn.)

For this literature circle 82 on inquiry card.

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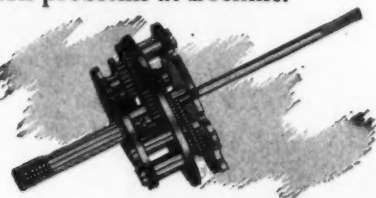
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January-February, 1959

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Single Indicator Simultaneously Monitor

A MAXIMIZING-Minimizing Bridge has been designed by Avien, Woodside, N. Y., to sense continuously the output of a system's many transducers and to select for measurement the one transducer having the highest output.

In one typical application this device is used to monitor the temperatures in three tanks of hydrogen peroxide. Here the pilot must know if any one of the three gets too hot, because excess temperature is an indication of an approaching dangerous condition. The Maximizer lets him watch for dangerous conditions in all three tanks while using only one indicator. With very simple modifications the single indicator could as easily monitor six, ten or a dozen temperatures at as many locations.

Maximizing Operation

Maximizing is accomplished by a simple but highly reliable static network of semiconductor diodes. In this network, changes in diode bias voltage resulting from changes in IR drop across the transducers biases off all diodes except the one connected to the transducer of highest resistance, which will conduct. The servo-driven self-balancing Wheatstone Bridge then adjusts a rebalance potentiometer (Fig. 1) which also drives an indicating pointer to a reading proportional to the value of the transducer with maximum resistance.

Minimizing is optionally accomplished by reversing the polarity of the transducer excitation voltages. The use of an external polarity switch then permits selec-

tion of either minimum or maximum indications at the will of the user.

Fail Safe and Test Features

To prevent any false indication which might result from failure of a transducer in the sensing system, transducer failure is signalled by an "open" indication.

Transducer failure indication is provided through the use of a zener diode in shunt with each transducer. Failure of a transducer will impress a relatively high voltage across the diode, causing it to conduct. Zener diodes have been chosen for low dynamic impedance so that only a low signal level will be seen by the amplifier, and the rebalance mechanism will drive down-scale to the "BULB OPEN" indication.

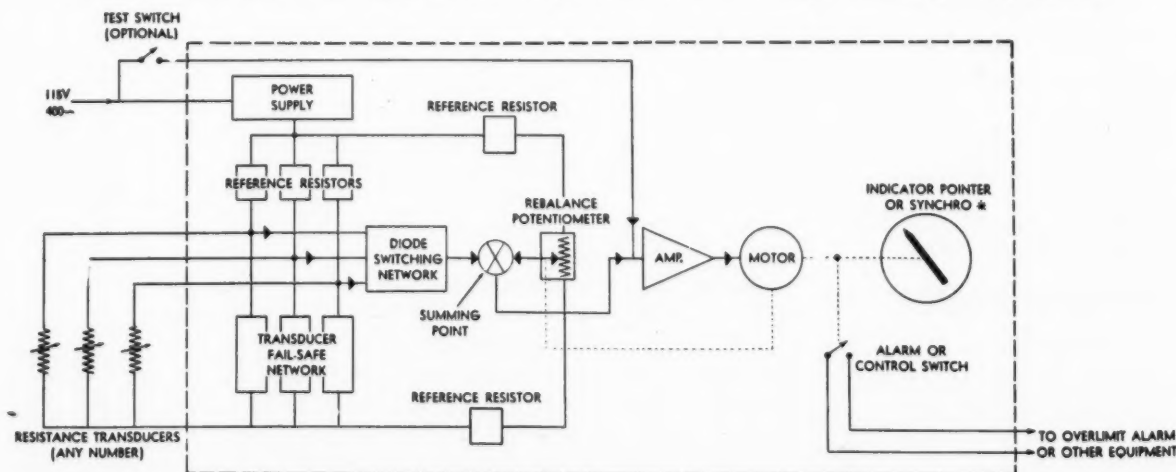
Power failure, whether internal or in the external wiring, is clearly indicated by means of an "OFF" flag visible through a cutout in the indicator dial (Fig. 2).

Proper operation may be tested at any time by bringing power at 115 v 400 cps into the indicator through an external push-to-test switch. Magnitude and phase of the test voltage is such that any bridge signal is over-ridden and the pointer is driven to the high end of the scale. Removal of the test voltage restores the indicator to normal operation.

Analog and Digital Outputs

For telemetering, recording, computing and similar applications, a second potentiometer or a digital en-

FIG. 1. SYSTEM BLOCK Diagram shows operation of Maximizing-Minimizing Bridge Circuit.

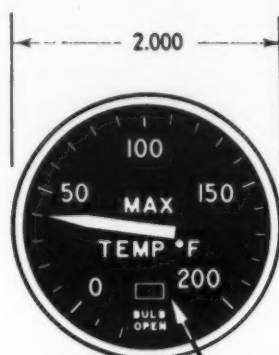


Many Transducers

coder can be incorporated into the unit, so that it is driven by the rebalance system to provide a signal output. Such systems can be supplied either with or without dials, to suit requirements.

Synchro repeaters also can be ganged to the rebalance system to drive a remote indicator. Also snap action or commutator type switches, operated by the rebalance mechanism, can be provided for over-limit warning or for control functions. Typical applications of the Avien Maximizing-Minimizing Bridge are shown in Fig. 3. (From 4-page Bulletin 135, *Maximizing-Minimizing Bridge*, by Avien, 58-15 Northern Blvd., Woodside 77, N. Y.

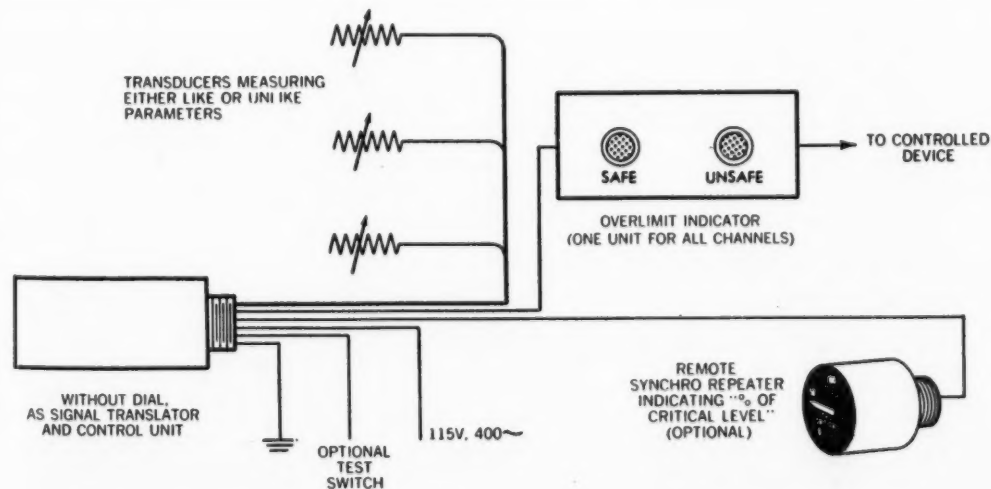
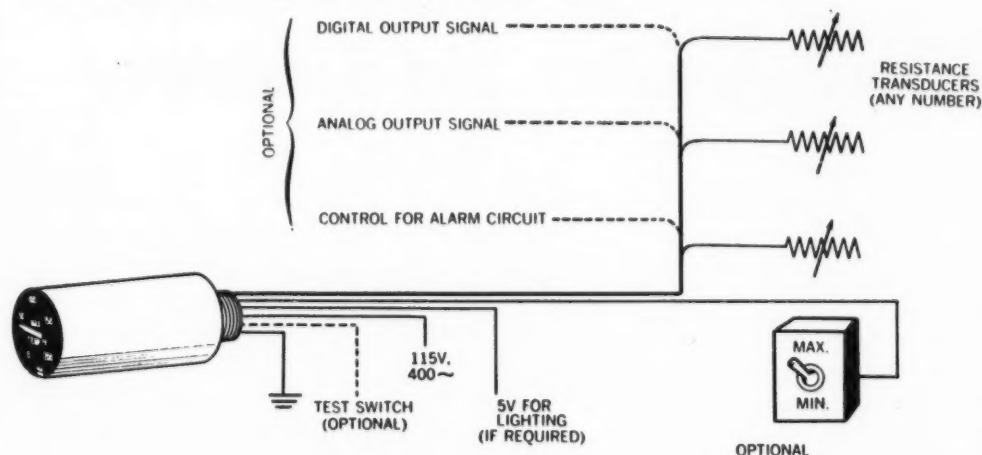
For this literature circle 83 on inquiry card.



POWER FAILURE INDICATOR
Legend "off" appears
when power is removed

FIG. 2. BRIDGE INDICATOR provides open circuit (Bulb Open), and "Power Off" indications through window. Entire bridge circuit is transistorized, contained in cylinder 5/8" long by 2" dia.

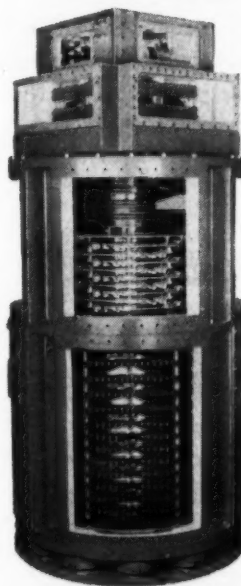
FIG. 3. TWO TYPICAL Applications. Many combinations and modifications of functions are practical, including telemetering and control.



When
it must
not fail

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BOOK REVIEWS . . .

FUNDAMENTALS OF ADVANCED MISSILES, 1958, by Richard B. Dow, AFOSR, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 567 p, 5 1/2" x 8 1/2", \$11.75. Discusses applications of basic principles, with numerous equations, and with attention to many research problems. One of Wiley Books in Space Technology.

STRAIN GAGE INSTRUMENTATION, edited by Milton Aronson and Robert C. Nelson. [c1958.] Instru-

ments Publishing Co., Pittsburgh 12, Pa. 104 p. \$2.00 8 1/4 in. Appeared serially in *Instruments and Automation*. Includes strain-gage principles, performance characteristics, sensitivity ratings, applications, and instruments and accessories.

ELECTRON TUBES AND SEMI-CONDUCTORS, by Joseph J. DeFrance. 1958. Prentice-Hall, Englewood Cliffs, N. J. 228 p. \$8. 9 1/4 in. Well-illustrated presentation with minimum of mathematics.

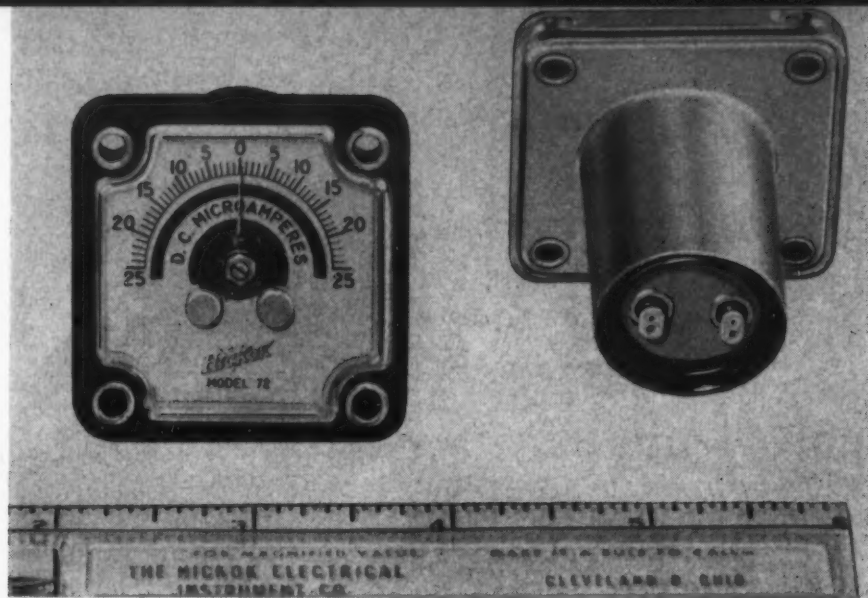


FIG. 1. RUGGED SUBMINIATURE meter retains scale and high sensitivity of larger, more delicate movements of conventional design.

Attempts to strengthen the shock resistance of meters of conventional design have also impaired the accuracy and sensitivity of those systems. Miniaturization also reached a limit set by the length of the meter's scale. Now a reduction of 50% in panel mounting space with no loss in accuracy but with a remarkable increase in ruggedness is provided by the new meter described below.

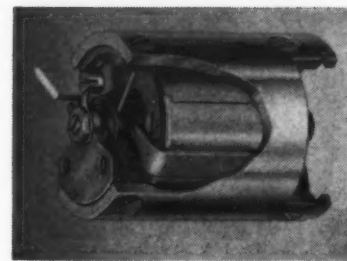


FIG. 2. CUTAWAY VIEW of 180° Scale Subminiature meter movement for dc and rectifier ac applications.

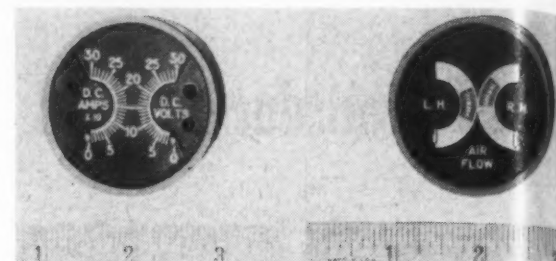


FIG. 3. STANDARD AN two-inch dia cases each enclose two 180° scale subminiature movements provide dual indication for related functions.

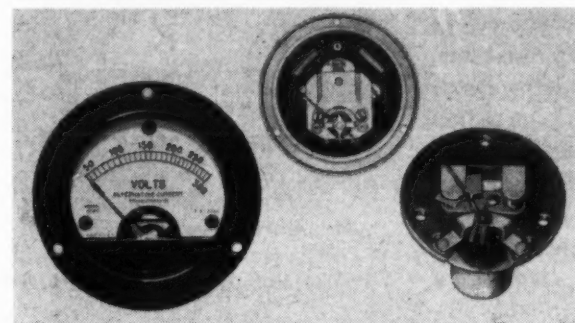


FIG. 4. RUGGEDIZED standard scale meters are available with ac and dc movements.

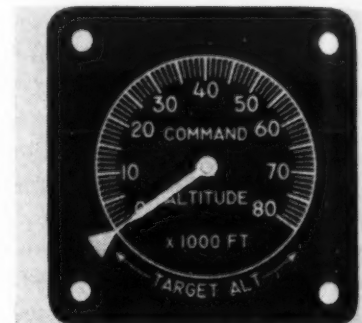


FIG. 5. 250° SCALE AIRCRAFT type meter has scale length of approximately 4 3/8".

Rugged Sub-Min Meter Has Large-Scale Accuracy and Sensitivity

A METER MOVEMENT which embodies new basic principles is credited for the ability of the new sub-miniature Hickok Model 72 DC Long-Scale meter to measure electrical currents to high accuracy while undergoing Mil-Spec tests. All the electrical and mechanical requirements of Mil-M-10304A are met, while accuracies of $\pm 1\%$ of full scale deflection are attained despite sub-miniaturization of the meter face to a 1 3/4" square, and shrinking of the meter movement to a rugged 1"-dia. 1"-deep cylinder (Fig. 1).

The new moving element (Fig. 2) is suspended from two bridge supports mounted on the outer pole piece which also shields the movement from external magnetic influences. An Alnico-V magnet is fixed to the outer pole piece and a crescent-shaped core is mounted on the magnet to form the inner pole piece. The shape of this core is carefully designed to extend the scale over 180° instead of the 90° arc commonly found in D'Arsonval type meters. New-type jewel-pivot systems used to support the moving element are said to withstand high impact shocks and vibration without affecting the accuracy or functioning of the meter.

The new sub-miniature element, less than 1" in diameter, is not only completely self-shielded but the

movement has desirable ballistic characteristics and high resistance to shock. A special mold design of rubber compound maintains correct movement position and protection under shock. The clear plastic meter front and barrel are then hermetically sealed as a unit to withstand thermal shock-by-immersion tests of 0° to 85°C, and to prevent entry of dust, humidity and mildew, enemies of sensitive meter movements everywhere. Under the high-impact hammer shock test these units have successfully withstood shocks to 1500-2000 G.

The new movement design also increases the needle arc-angle to 180° to provide 1.52" of scale in a 1 3/4" square face, approximately equivalent to that of a 2 1/2" round meter with a conventional scale.

The Model 72 Subminiature Long-scale meter is available in all standard dc or ac-rectifier ranges down to 50 microamperes. This high basic sensitivity, coupled with the meter's accuracy, ruggedness and subminiature size should make practical the miniaturization of a host of line-servicing and maintenance meters which now burden electrical and electronics maintenance crews in the Armed Forces. It will also allow further miniaturization of military communica-

tions, aircraft cockpit panels and missile checkout equipment.

Another advantage of the long-scale subminiature movement is shown in Fig. 3, where two meters or meter-type indicators are enclosed in a single standard AN type 2" case. In many applications, as when two conditions must quickly be compared, the juxtaposition of the two indicators will enhance the readability of the indication.

Other instruments developed by the Hickok Electrical Instrument Co., Cleveland 8, Ohio, to meet military specification requirements with aircraft and missile applications in view are the ruggedized standard-scale arc round panel meters (Fig. 4), made with dc and ac movements; and the new ruggedized 250° long scale meters (Fig. 5) in 2 1/2", 3 1/2" and 4 1/2" round cases. Accuracy of the standard-scale-arc instrument is $\pm 1 1/2\%$ standard (1% on special order). The 3 1/2" 250° long-scale meter provides evenly spaced divisions over a scale length of 5 1/2", equivalent to a standard 6" switchboard meter. Its standard accuracy is $\pm 1\%$ of full scale, to $\pm 1/2\%$ on special order, and is available in dc and ac-rectifier ranges with a maximum sensitivity of 50 micro-amperes, full scale deflection.

For more information on Hickok ruggedized and long-scale meters circle 84 on inquiry card.

CERAMIC DISC CAPACITORS PROMOTE RELIABILITY

TC (Temperature Compensating) ceramic disc capacitors (Fig. 1) are specifically suited for resonant circuit application or anywhere high Q and stability of capacity characteristics are essential. They are characterized by high Q value, high insulation resistance, a very low aging rate and high dielectric strength.

TS (Temperature Stable) ceramic disc capacitors are designed for use where a minimum capacitance change with temperature is required. These units have exceptional temperature stability over the extended temperature range of -55°C to 125°C . (Fig. 2).

GP (General Purpose) ceramic disc capacitors are suited for non-critical circuits where Q and stability of capacitance characteristics are not of major importance. Type "GP" units provide very high capacity in relation to size, are after called the "space-saving" capacitors.

All El-Menco Ceramic Disc Capacitors withstand the life test and seal test (thermal cycle and humidity) per E. I. A. specification RS-198, are also available in 1000 wv dc and 2000 test volts dc per I. E. A. specification RS-165.—(From 6-page folder, "The Ultimate in Reliability", The Electromotive Mfg. Co., Inc., Willimantic, Conn.)

For this literature circle 85 on inquiry card.

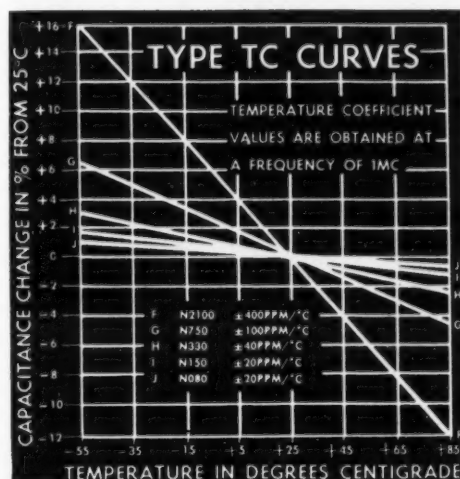
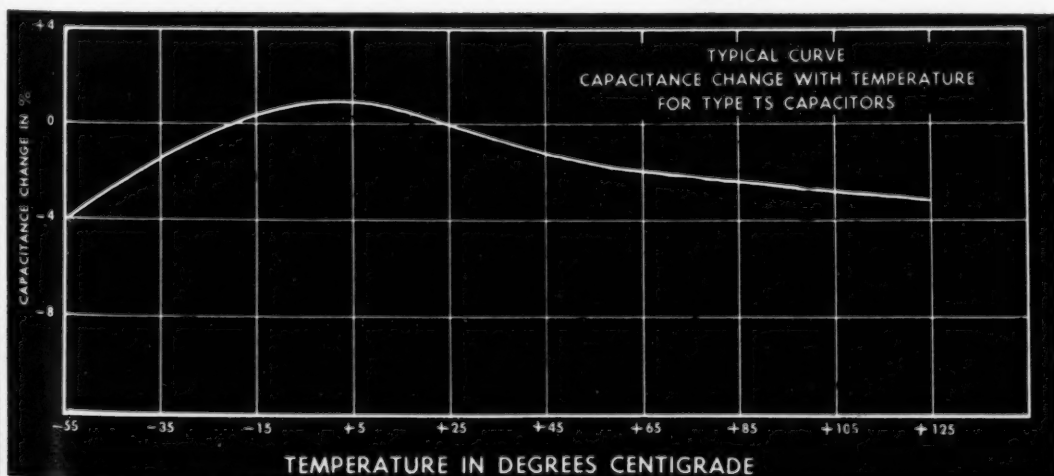


FIG. 1. RELIABLE temperature compensation by Type TC capacitors.

FIG. 2. TEMPERATURE STABILITY is feature of Type TS ceramic capacitors.



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"THE MOST" features

The most shock and vibration resistance—*Patented Floating Body Isolation guarantees vibra-shock protection and operation by complete separation of electrical contact body from mechanical elements.

The most comprehensive line—Single units have 34-41-50-75 contacts. Modular multiple connectors have 123-150-225 contacts. Other configurations upon request.

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Also available in Hoodless Knob Type

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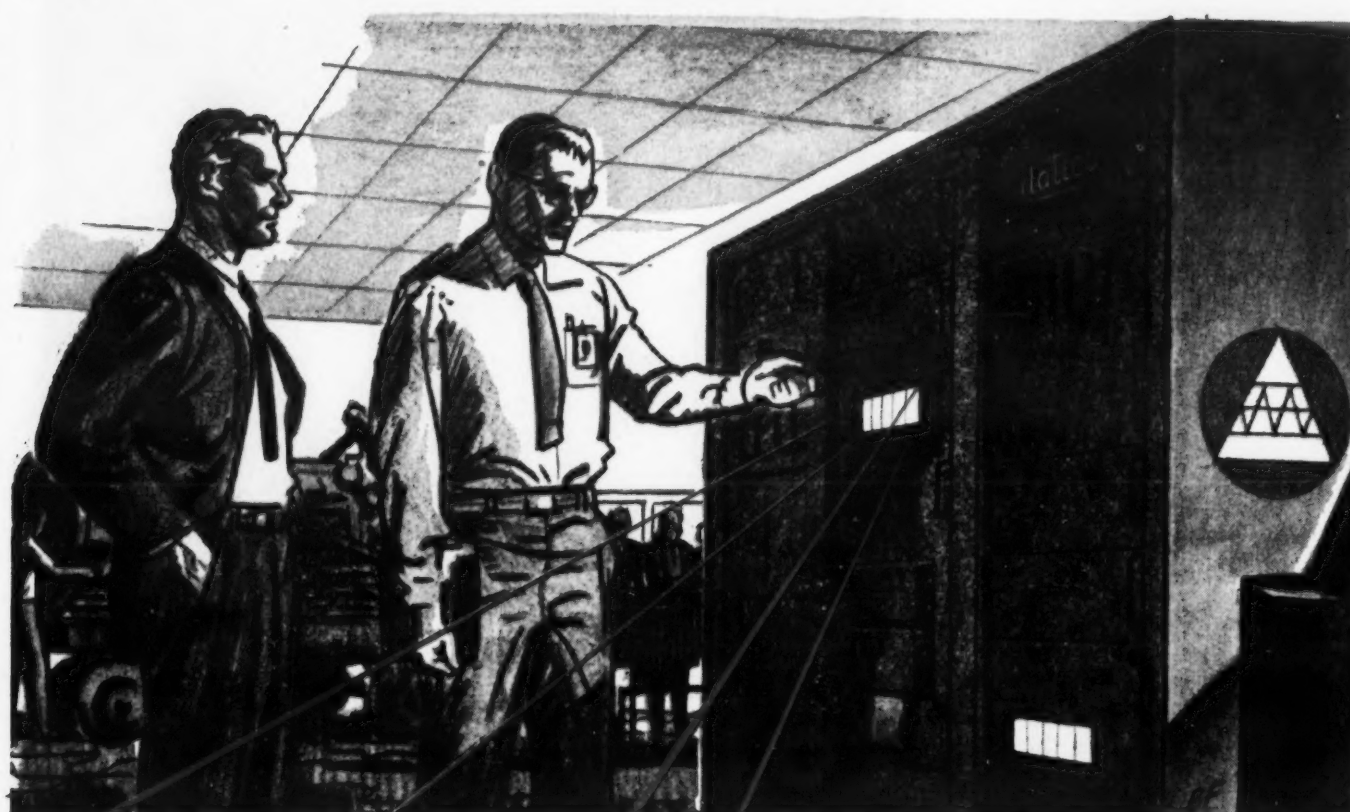
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For more information circle 21 on inquiry card.

Transistorized NLS M-24 Selected for Missile Checkout System



+24.00

Analog to digital conversion in Nortronics' Universal Datico is accomplished by the ultra-reliable NLS M-24, the transistorized Digital Volt-Ohmmeter that automatically and accurately measures and displays AC and DC voltages, voltage ratio and resistance.

In Datico, program control is performed by a punched paper tape. Test stimuli are automatically controlled by Datico and output signals (voltage, voltage ratio, and resistance) from the system under test are automatically selected and fed to the NLS M-24. The M-24 digitizes the system outputs to 0.01%, and provides numerical data to the indicator and control chassis for distribution to the data recorder, digital comparator, and visual display on a special NLS in-line readout.

The tape also establishes the go-no-go limits for comparison with the M-24's digital output. It then directs the system to the next channel to be measured.

Operation of the NLS M-24 in this system is completely automatic . . . the instrument is remotely operable, does not require zero setting, and is extremely stable over very long time periods. Over-all system speed is not compromised by analog to digital conversion time, the M-24 making each measurement in just 330 milliseconds.

The NLS M-24 meets the unusually great reliability demanded of automatic test equipment for modern electronic weapons systems. This reliability is assured by transistors, mercury-wetted contact relays (rated at 10 billion measurements), advanced circuit design, and thorough production and field testing.

Proved in the field in a variety of applications, the NLS M-24 Digital Volt-Ohmmeter is in production and ready to go to work for you. Write today for detailed information concerning this outstanding example of NLS leadership in the development and manufacture of digital instruments. A complete catalog of NLS instruments will be sent upon request.



Originators of the Digital Voltmeter

non-linear systems, inc. DEL MAR (San Diego), CALIFORNIA

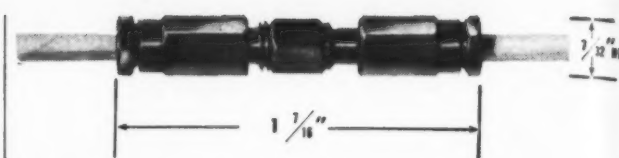


FIG. 1. HEXAGONAL BODY and nuts of new connector enable easy rewiring of subminiature coaxial cables in field using common pocket tools.

HEX COAX CO

NEW miniature 'ConheX' connectors (Fig. 1) are designed to meet severe environmental conditions such as encountered in missiles, aircraft, computers, closed-circuit TV and radar, where weight and space limitations dictate the use of the new sub-miniature MIL-Spec cables. They feature a strong clamping action, captivated contacts, telescoping insulators, ease of assembly and a low VSWR at micro-wave frequencies. 'ConheX' connectors are a development of the Sealectro Corporation in Mamaroneck, N. Y. and patents are pending.

'ConheX' cable clamp design, as shown in Fig. 2, utilizes: (1) A specially molded resilient compound gasket which, when compressed by the clamp nut at the back of the body, exerts pressure against the cable jacket and that section of the braid immediately under the jacket; and (2) a metal sleeve which is inserted between braid and cable dielectric to hold the pressure exerted by the gasket, insuring an excellent electrical contact with the braid and preventing any deformation of cable dielectric.

This gasket pressure also insures proper electrical contact between the sleeve and the body and guarantees a satisfactory resistance to pull out strain on the cable. Captivated contacts insure proper engagement with mating parts, particularly important when making up short cable assemblies. Telescoping insulators provide a long leakage path reducing any tendency for flash overs.

The hexagonal-shaped nuts and bodies permit the use of common and generally available pocket tools for wiring and rewiring on the job anywhere, greatly simplifying the task of the installer or maintenance man.

Provision for soldering of the center contact to the center conductor of the cable provides reliable contact at this important point. Also, firm positive contacts on both braid and inner conductor, without deformation of the dielectric brings a new degree of reliability to that sector of electronic system design that had been particularly vulnerable in the past. All metal parts are

NLS — The Digital Voltmeter That Works...And Works...And Works!

For more information circle 22 on inquiry card.

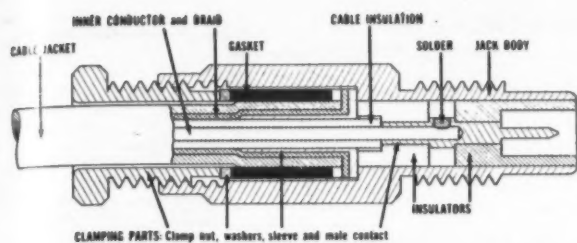


FIG. 2. SUB-MINIATURE DESIGN provides high pullout strength with positive electrical contacts and no deformation of cable dielectric.



FIG. 3. CONHEX CONNECTORS, in 50 and 75 ohm series, are now available in the six types shown.

TABLE I. APPLICABILITY OF 'CONHEX' SERIES 3000 CONNECTORS WITH SUBMINIATURE MIL-CABLES

Subminiature Cable Type No.	Outer Jacket OD	Inner Conductor OD	Characteristic Impedance	Applicability
RG-188/U	0.110"	0.020"	50 ohm	Designed for
RG-187/U	0.110"	0.012"	75 ohm	Used with slight mismatch
RG-196/U	0.080"	.012"	50 ohm	Special clamping parts required
RG-195/U	0.155"	.012"	95 ohm	Use with 75 ohm series connector

The applicability of the 'ConheX' series 3000 to the newest MIL-Spec subminiature cables is shown in Table 1. Of the four cable types, the 50 ohm connector can be used directly with the RG-188/U and the RG-187/U cables. While a slight mismatch may occur through the connector when used with the RG-187/U, 75 ohm cable, it is said to be practically negligible, particularly at the lower frequencies. In fact, use of 50 ohm connectors with this cable was anticipated when the cable was designed. The RG-196/U cable can also be used with the series 3000 connectors by changing the clamping parts which are the clamping nut, washers, gasket and sleeve to accommodate the difference in diameters of the cable components.

For detailed "ConheX" specifications circle 86 on inquiry card.

AX CONNECTOR FITS SUB-MIN CABLES

machined brass except for the female contacts which are beryllium copper, heat treated. Insulators are Teflon, and the finish on all metal parts is gold plate over copper.

The new connectors, designed in 50 ohm and 75 ohm impedance sizes for use with the latest MIL types of sub-miniature cables, are suitable for use at microwave frequencies. Types for the 50 ohm, 3000 series, shown in Fig. 3, include the cable plug, cable jack, bulkhead receptacle, bulkhead jack, cable feed-thru

and right angle plug; all of which accept the RG-188/U MIL cable and RG-174/U or other cables having similar component diameters.

The 75 ohm series is slightly larger in size than the 50 ohm connectors but is made in the same types. While designed primarily for *miniature* 75 ohm cables, larger than the RG-187/U, they can also be used to advantage with subminiature 95 ohm cables such as the RG-195/U or other cables having similar component diameters.

Why Use Choppers?

There ought to be something wrong with using electro-mechanical devices to perform electronic functions. Or at least, this seems obvious to many of us for whom moving devices are anathema. Also, there are several other ways of performing the chopper function; and, it is fair to ask, why use choppers at all?

Magnetic modulators, for example, provide probably the most reliable substitute, the second harmonic type having considerably better zero stability than the fundamental type. Fig. 1, compares various modulator systems.

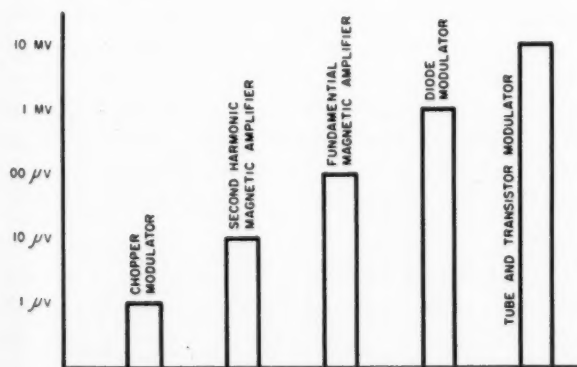


FIG. 1. NULL STABILITY of various types of modulator systems under laboratory conditions.

The chart in Fig. 2, assuming a carrier frequency of 400 cps, shows the frequency response limits of various modulation methods.

The chart shown in Fig. 1, described the minimum practical offset obtainable from a variety of modulation methods. No such chart can present a full picture, obviously there are other limits such as frequency response, circuit impedance, and temperature range. One of these limits was found in Fig. 2. And, since these are minimums, the limits also depend on other engineering interpretations. The closest approach to chopper stability, the second harmonic magnetic modulator, is limited by slow response,

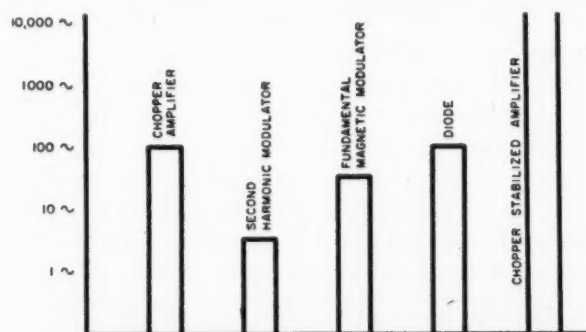


FIG. 2. FREQUENCY RESPONSE limits of modulator systems.

about 1 to 3 cps; by temperature changes, which give poorer stability; and by second harmonics in the power source, which causes offset. Airpax makes all of these modulation devices.

The first question is whether or not a chopper is needed. Other than modulation of dc, you may want to compare two dc signals, to switch radio frequency signals, to provide a time sharing method, to stabilize another amplifier, to provide a filter circuit, to demodulate or rectify signals, or to sample data. If your problem is in the zero frequency region you will probably need a chopper if:

- You need high impedance circuits, over 1,000 ohms.
- Response time greater than 2-10 cps is required.
- Null stability must be better than one millivolt.
- Or null stability must be better than several millivolts under wide temperature ranges.
- You must have performance over about 85°C.
- You are limited by space and weight.
- You are limited by your budget.
- You have limited power.
- Your system is exposed to atomic radiation.
- The signal to be modulated has a very wide dynamic range.
- Extreme linearity is demanded, as for digital conversion.
- 5,000 hours life expectancy is sufficient.

(From 24-page booklet, "The Contact Modulator, Airpax Products Co., Seminole Div., Ft. Lauderdale, Fla.).

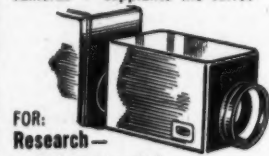
For this literature circle 87 on inquiry card.

ZOOMAR OPTICS

FOR COMMERCIAL AND MILITARY APPLICATION



REMOTE CONTROLLED LENSES FOR CLOSED CIRCUIT TELEVISION
adaptable to all standard ITV vidicon cameras • supplants the turret



FOR:
Research—
Nuclear, Aircraft &
Missile, Industrial
Security
Production and Automation

MARK II—Dual Range 1:6
F/3.5—22mm to 130mm
F/5.6—35mm to 210mm

MARK IV—F/2
Zoom Range: 1:4
F/2—17mm to 70mm

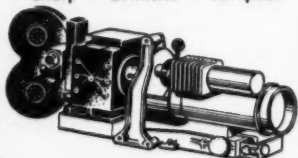
MARK VI—Dual Range 1:6
F/3.5—25mm to 150mm
F/5.6—40mm to 240mm
• High resolution • High contrast
• High speed • Compact • Light-weight • 110 V, AC Control Box

FOR:
LOW LIGHT LEVEL operation of
Closed Circuit Television • Fits
all standard ITV cameras



ZOOMATAR
F/1.3 • F = 75mm • "C" mount
thread
• High Speed • Sharp • Brilliant

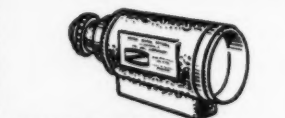
TELEPHOTO LENSES for special
purpose Motion Picture and
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20"—F/5.6
25"—F/6.3
40"—F/8

80"—F/15
100"—F/20
150"—F/25



ZOOMAR LENSES
for image Orthicon TV cameras



SUPER STUDIO ZOOMAR
(Manual or Remote Control)
Speed: F/2.8 • Zoom range: 1:3
Focal Length: 2½" to 16"
Distance Range: 10' to infinity

SUPER UNIVERSAL TV ZOOMAR
(Manual or Remote Control)
3 Zoom Ranges: 2½" to 16" at F/3.9
4" to 25" at F/5.6
6½" to 40" at F/8
Focal Length: 2½" to 16"
Distance Range: 20' to infinity

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For more information circle 23 on inquiry card.



FIG. 1. PROTECTION for sensitive wind-tunnel pressure transducers is afforded by new Gage Gard Jr valve which can be used even in subatmospheric pressure applications.

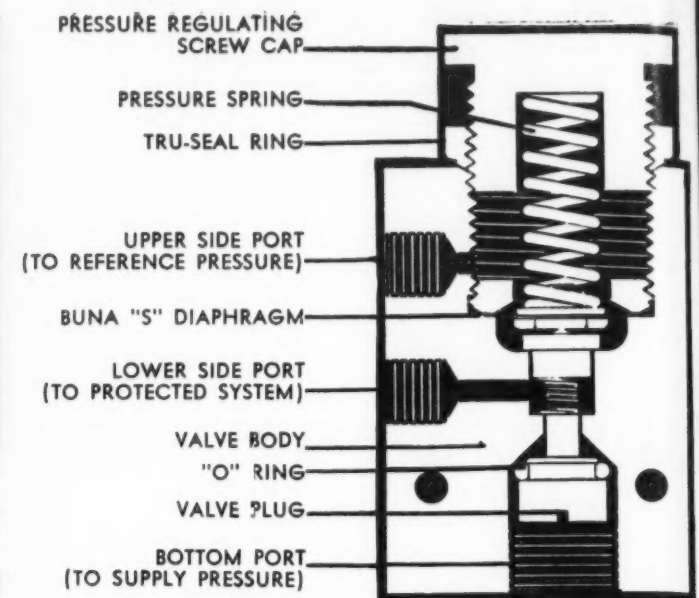


FIG. 2. REFERENCE PRESSURE plus spring pressure balances against supply pressure, holding valve open. Excessive supply pressure closes valve to protect instruments, automatically reopens when safe supply pressure is restored.

Low-Pressure Instrument Protector

WIND TUNNEL engineers number among their concerns the condition and accuracy of the many sensitive detecting and recording devices associated with the tunnel instrumentation. Incline manometers, draft gages and ultra-sensitive low pressure transducers are delicate instruments which can be damaged or their calibration impaired by too great excursions in pressure differential above normal range.

High pressure instruments have been protected for many years by a reliable protective device, called the Gage Gard, developed by the Industrial Engineering Corporation of Louisville, Ky. However, these devices, with cutoff ranges from 10" of water to 9000 lbs psig, operate only against the ambient atmospheric pressure. In many wind tunnel applications, the ambient pressure changes so radically as to make the cut-off point of such a valve meaningless. Also, previous models did not protect instruments which measured sub-atmospheric pressures.

Designed particularly for low-pressure wind tunnel and environmental chamber testing, the new Gage Gard Jr. (Fig. 1) is supplied with three ports. The bottom port (Fig. 2) is connected to the pressure source, the lower side port to the instrument or system to be protected, and the top port to a set reference pressure. As long as the reference pressure is maintained constant, the Gage Gard Jr. will cut off when the supply pressure exceeds the value for which it has been set. When the supply pressure drops 2% below the cut-off value, the Gage Gard Jr. valve reopens.

When the supply pressure against the BUNA-S diaphragm exceeds the reference pressure plus the spring tension, the diaphragm rises, raising the valve plug until the "O" ring seals against the valve body.

As an example of a typical application, a Gage Gard Jr. is used to protect a pressure transducer having a 0-10 psi differential from overrange supply excursions. The supply pressure is from a test chamber which may vary from 10-30 psi absolute. Since the lower range of the source pressure is subatmospheric, a subatmospheric reference pressure of 10 psia must be connected to the top port. If the source pressure exceeds 20 psia (or 10 psi differential) the valve will close, isolating and protecting the transducer.

The top port connection may also be used to control the cutoff point of the Gage Gard Jr. from a remote location as follows: If the Gage Gard is set to cut off at 10 psi, and a vacuum of 10" of mercury is applied to the top port connection (10" of vacuum equals approx. 5 psi), the Gage Gard will cut off at 5 psig. If 20" of mercury were applied, the Gage Gard would cut off at 0 psig. Conversely if a positive pressure of 10 psi is applied, the Gage Gard cuts off at 20 psig.

On applications where the Gage Gard Jr. is always used in atmospheric pressure, the top connection is left open.

All Gage Gards operate on the same principle; i.e., the pressure from the source on one side of a diaphragm is balanced by the spring and atmospheric

TABLE 1. GAGE GARD PROTECTION PRESSURE RANGES

	Gage Gard Jr. psig	Gage Gard, GG-1 psig	Gage Gard, GG-2 psig
Cut-off Pressure	-10 to +10	20" water ¹ to 5	100 to 300
Ranges	-15 to +15 0 to +25 0 to +85	4 to 25 5 to 50 10 to 125	250 to 1200 1000 to 4000 3000 to 9000
Max Body Pressure	300	10,000 (1 Except first range, 100 psig)	10,000

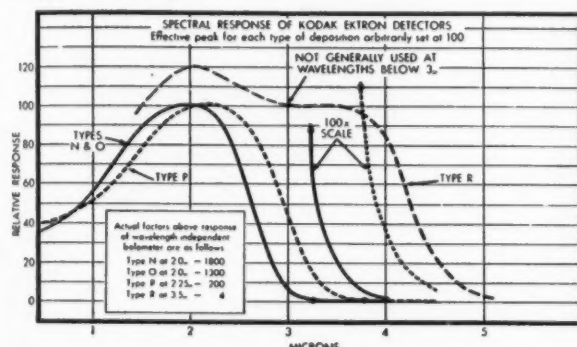
(or reference) pressure on top of the diaphragm. Adjustment of the cut-off point is made by changing the spring tension. Over-pressures up to 300 psi can be allowed in the Gage Gard Jr. after cut-off. Ranges from minus 15 psig to plus 15 psig up to 0 psig to plus 85 psig are available as shown in Table I. Although the cut-off pressure will be factory-set at the value requested by the customer, the Gage Gard can be reset to any value in its range at any time.

For bulletin 547-G circle 88 on inquiry card.

Photoconductive Detector Characteristics

Kodak Ektron Detectors are specified by a letter-numeral combination, e.g. Type N-2.

The letter indicates response characteristics. Comparison is on basis of response to 500°K radiation, chopped at 90 cps.



- N** Lead sulfide of maximum response. Time constant in the order of 400 to 1000 micro-seconds.
- P** Lead sulfide with one-quarter the response of N. Time constant near 100 micro-seconds. Better response than N and O beyond 3 microns at room temperature. Can be extended to 4 microns by cooling.
- O** Lead sulfide with two-thirds the response of N. Time constant in the order of 200 to 500 micro-seconds.
- R** Lead selenide with time constant characteristically less than 10 micro-seconds at 25°C. Response about 3% of N, but useful spectral sensitivity extends to 4.5 microns uncooled and to 5 microns at -70°C, with time constant increasing to 10 to 50 micro-seconds at the low temperature.

The numeral indicates physical form.—(From 4-page data Sheet, Kodak Ektron Detector, Military and Special Products Sales, Eastman Kodak Co., Rochester 4, N. Y.).

For this literature circle 89 on inquiry card.

KEARFOTT TACHOMETERS

...compact, light-weight, high-performance

Kearfott offers one of the broadest lines of precision tachometers in the industry. Light, compact and resistant to temperature, vibration and shock, they are available for a wide variety of applications.



Size 11 (R860)

Integrating Tachometers, special types of rate generators, are almost invariably provided integrally coupled to a motor. They feature tachometer generators of high output-to-null ratio and are temperature stabilized or compensated for highest accuracy integration, rate computation, etc. In addition to reducing the in-phase null level toward zero, errors due to temperature effects are minimized over a wide ambient range. Linearity, in some cases as low as .01%, is usually better than $\pm 1\%$, while phase shift is $0 \pm 1^\circ$. For extreme accuracy, models with low temperature coefficient drag cups are also available.

Rate Generators feature high output-to-null ratios and are designed for application as rate servos and to provide damping in very high gain systems. These Kearfott units offer high linearity, high output and low inertia and are often integrally coupled to a low inertia motor; in this design the in-phase null is virtually reduced to zero. Quadrature null is as low as .25% of the 1000 rpm outputs while harmonics seldom exceed .1% of the output at 1000 rpm.

Damping Tachometers have relatively low output-to-null ratios and are designed primarily for damping purposes. They feature extremely low inertia and power consumption, linearity which is normally within $\pm 5\%$, and phase shift within 10° of reference. Kearfott damping tachometers are usually integrally coupled to a low inertia motor.

INTEGRATOR TACHOMETERS (Typical Characteristics)

	Size 11 (R860)	Size 15 (T816)	Size 18 (V892)
Excitation Voltage (400 cps)	115	115	115
Volts at 0 rpm (RMS)	.020	.020	.010
Volts at 1000 rpm (RMS)	2.75	2.7	2.00
Phase shift at 3600 rpm	0°	0°	0°
Linearity at 0-3600 rpm	.07	.05	.07
Operating Temperature Range	-54° + 125°	-54° + 125°	-54° + 125°

RATE TACHOMETERS | DAMPING TACHOMETERS (Typical Characteristics)

	Size 15 (R800)	Size 18 (V806)	Size 8 (M824)	Size 10 (P822)	Size 11 (R809)
Excitation Voltage (400 cps)	115	115	26	115	115
Volts at 0 rpm (RMS)	.013	.026	.015	.019	.019
Volts at 1000 rpm (RMS)	3.1	3.0	.234	.450	.5
Phase shift at 3600 rpm	5°	4.5°	10°	5°	5°
Linearity at 0-3600 rpm	.25	.25	.3	.3	.3
Operating Temperature Range	-54° + 100°	-54° + 125°	-54° + 125°	-54° + 125°	-54° + 125°

INTEGRAL SERVO MOTOR DATA (Typical Characteristics)

	Size 8	Size 10	Size 11	Size 15	Size 18
No Load Speed (RPM)	5400	6600	5500	8000	8000
Stall Torque (oz. in.)	.3	.35	.55	.45	1.30
Excitation Voltage (400 cps)	18-40	26-40/20	115-40/20	115-40/20	115-115/57.5
Rotor Moment of Inertia (Gm.CM ²)	1.3	.76	7.7	7.0	35
Operating Temperature Range	-54° + 100°	-54° + 125°	-54° + 125°	-54° + 125°	-54° + 125°
Unit Weight (incl. tachometer)—oz.	3.1	4.6	9.0	14.0	30

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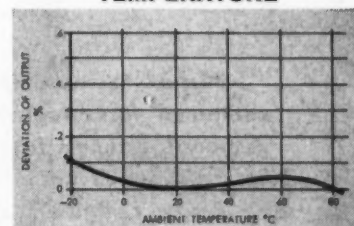
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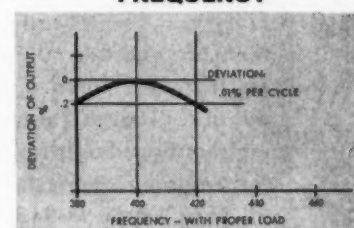
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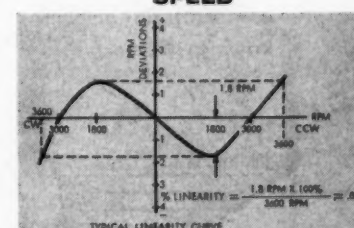
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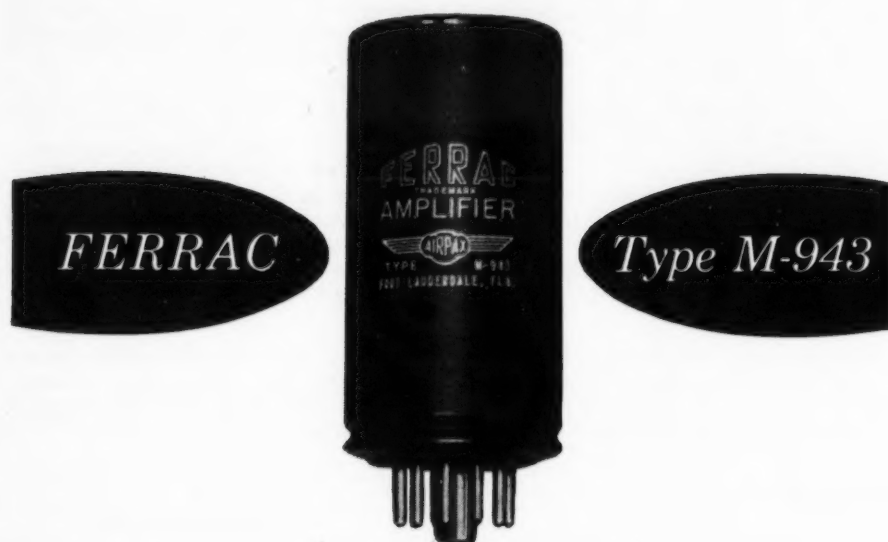
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AIRPAX ELECTRONICS

INCORPORATED

Note our name change:
Formerly THE AIRPAX PRODUCTS COMPANY



Airpax Ferrac amplifiers are exceptionally stable self-contained ferromagnetic computing amplifiers. Frequency response extends from DC to an upper limit determined by the input circuit.

Ferrac amplifiers are powered from 115 volt 400 or 60 CPS sources and are unusually insensitive to fluctuations in supply voltage or frequency. Potted for mechanical stability and hermetically sealed for environmental protection, their life exceeds 10,000 hours. Input (control) windings are electrically isolated and the output is insulated from the input and ground. These features permit signal mixing, phasing, limiting, integrating and all analog functions necessary for automatic control.

Ferrac type M-943, illustrated, is for use in commercial and military airborne control equipment and industrial automatic controls where extremely stable operation is essential. Other Ferracs are available, with rectangular packaging, having solder hook terminals and mounting studs.



SM14

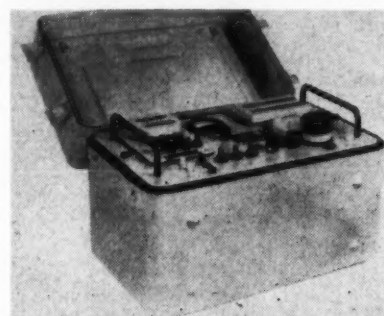
SEMINOLE DIVISION, FORT LAUDERDALE, FLORIDA

For more information circle 25 on inquiry card.



PORTABLE TACAN SIMULATOR

Test instrument Model HLI-119 simulating Tacan ground beacon simulates a signal on any two of 126 TACAN or DMET channels to provide checks of range and bearing



operation, coding and decodings, operating frequency, peak power and receiver sensitivity.—*Hoffman Electronics Corp., 3761 S. Hill St., Los Angeles 7, Calif.*

For more information circle 90 on inquiry card.

MULTITURN POTENTIOMETER

New 25 turn ultra-precision potentiometer, Model MD 20-25, meets or exceeds all critical MIL-specs for potentiometers, has linearity up to 0.0075% and very high resolution.

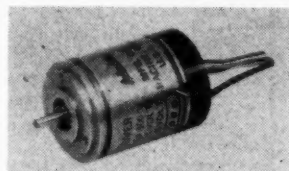


Available with wire leads or terminals; bushing or servo mounts.—*Components Div., Litton Industries, Inc., 215 S. Fulton Ave., Mount Vernon, N. Y.*

For more information circle 91 on inquiry card.

SIZE 10 SYNCHRO-RECEIVER

Precision size 10 meeting MIL-I-7057 for indicator applications has -55° to 71°C ambient range, 1° dynamic test accuracy and 5 seconds

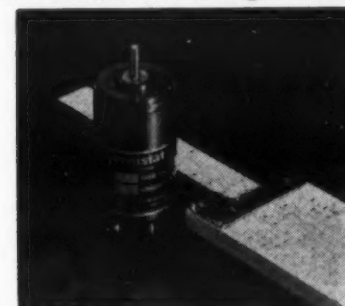


damping. Torque gradient, 220 mg-mm/°; rotor moment of inertia 2 gm-cm²; input voltage 26 v, 400 cps; output is 11.8 v.—*John Oster Mfg. Co., 1 Main St., Racine, Wisc.*

For more information circle 92 on inquiry card.

MINIATURE "VERNISTAT"

New size 11 (1.062" dia) Series 4 Vernistat potentiometer using same principles as larger series, combines a precision multitapped autotransformer with a multiturn interpolating potentiometer for relating mechanical shaft rotation to voltage. Features

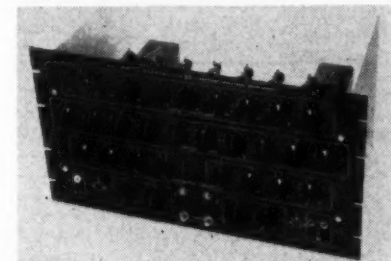


high input impedance, low maximum output impedance, minimum resolution of 0.01% and terminal linearity of 0.05%. Non-linear versions with 30-chord accuracy are used in Century Series flight simulators.—*Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle 93 on inquiry card.

NONLINEAR COMPONENT

New Model FF Function Fitter is a self-contained rack-mounted analog computing component for the simu-

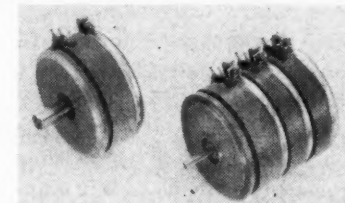


lation of arbitrary functions of the input voltage. It features 10 straight line segments with adjustable tangent parabolic rounding, and adjustable slopes, break points, and offset.—*George A. Philbrick Researches, Inc., 285 Columbus Ave., Boston 16, Mass.*

For more information circle 94 on inquiry card.

PRECISION POTENTIOMETERS

New Type 757 precision potentiometers in both linear and nonlinear applications, can be ganged in up to 8-cup combinations, using an exter-



nal flush clamp band which does not increase overall diameter. Standard units operate in ambients from -55° to 85°C. High temperature versions operate under load to 150°C. Detailed specifications on request.—*Components Div., Fairchild Controls Corp., 225 Park Ave., Hicksville, L. I., N. Y.*

For more information circle 95 on inquiry card.

HELICAL POTENTIOMETER

New Model 1410, a 1-w, 200- to 25,000-ohm sub-miniature Pot, with shaft, front bushing and bearing manufactured from corrosion resistant Nickel Silver (18% Ni), and wiping contacts fabricated from noble

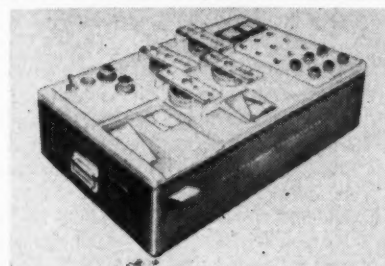


metal laminates. Will withstand accelerations of up to 50 G's in three planes without electrical or mechanical damage and without wiper deviation from a set mechanical angle. Guaranteed to meet all applicable requirements of JAN-R-19, JAN-P-13, JAN-P-79, JAN-R-38 and to withstand the environmental conditions of MIL-E-5400.—S. A. Asquith Co., 427 W. Chevy Chase Dr., Glendale 4, Calif.

For more information circle 96 on inquiry card.

POTENTIOMETER CHECKER

New test unit PC-15 consists of 10-turn master potentiometer, coupling and phasing unit for potentiometer under test, drive mechanism

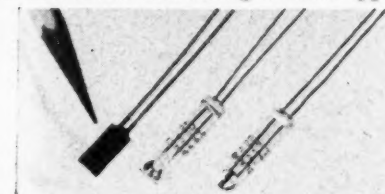


for potentiometers and recorder paper, recorder, trimming facilities for zeroing and error, and calibration source. Accuracy on 1-turn output shaft is 0.01%; on 15-turn output is 0.003%.—Analogue Controls, Inc., 39 Roselle St., Mineola, N. Y.

For more information circle 97 on inquiry card.

MINIATURE PHOTOCELLS

New line of photoconductive miniature cells, sealed in glass or plastic-encapsulated, may be soldered directly into a circuit without employing a heat sink. Consisting of two types,



polycrystalline cadmium sulfide and cadmium selenide, thirteen different cells cover the visible spectrum and beyond, for applications in ambients from -50° to 75°C. 10-page brochure gives technical characteristics, applications.—Clairco Corp., W. 26th St., New York, N. Y.

For more information circle 98 on inquiry card.

SPEED CHANGER KIT

New Bantam Speed Changer Kit provides 29 different ratios—from 1:1 to 44:1. Housings, bearings, gears, and shafts may be used repeatedly. Gears are 48 pitch, 20° pressure angle spur gears of case-hardened steel. In-

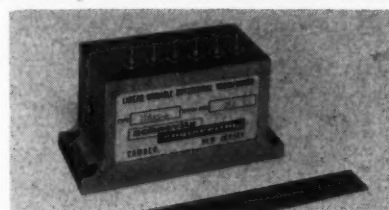


put and output shafts run in 2 ball bearings on each shaft, and countershafts run in ground needle bearings. Ratings: torque—130 in oz max. at low-speed shaft; speed—10,000 rpm max. at high-speed shaft; and horsepower—0.1 hp max. at low-speed shaft.—Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.

For more information circle 99 on inquiry card.

HEAVY DUTY DIFFERENTIAL TRANSFORMER

New Linear Variable Differential Transformer consists of a shielded LVDT potted in an anodized alumi-

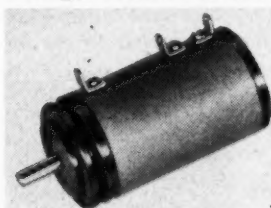


num case for resistance to oil immersion. Space is provided in case for additional components such as temperature-compensating networks, phase-shifting networks, etc.—Schaevitz Eng., Route 130 & Schaevitz Blvd., Pennsauken, N. J.

For more information circle 100 on inquiry card.

PRECISION 10-TURN POT

New Model 870 10-turn precision wire wound potentiometer is available in ranges from 30 to 750 K ohms



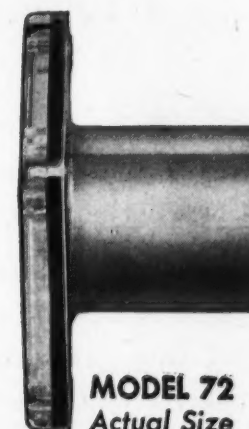
with a standard linearity tolerance of $\pm 0.3\%$. Also can be provided with special non-linear functions computed to customer's requirements. As many as 91 extra terminals can be added to meet specified requirements.—Spectrol Electronics Corp., San Gabriel, Calif.

For more information circle 101 on inquiry card.

HICKOK EXCLUSIVE RUGGEDIZED LONG SCALE SUB-MINIATURES

1" barrel 1% accuracy 1" depth

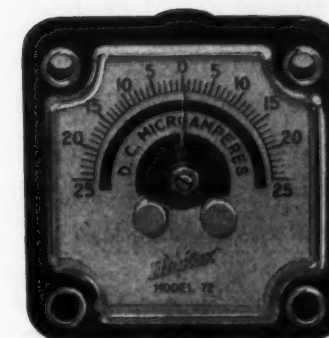
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- ★ RUGGEDIZED & SEALED
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(to 50 microamperes)
- ★ PRECISION ACCURACY
(to 1% of full scale)



MODEL 72
Actual Size

This unusual instrument development meets all the requirements of MIL-M-10304A as applicable, and is available in all standard DC ranges.

The completely self-shielded 180 degree arc-angle movement features a new type pivot with a new reinforced jewel holder and other construction advantages designed to withstand exceptionally high impact and vibration without impairing the accuracy or functioning qualities of the meter.



ALSO AVAILABLE

- 2-1/2", 3-1/2" and 4-1/2" round case styles with standard scale lengths in AC or DC ruggedized types.
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(Form MSM and Catalog 39 are available at your request.)

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For more information circle 26 on inquiry card.

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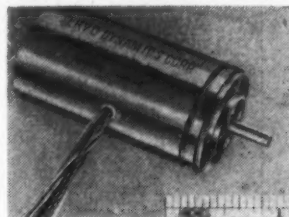
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SIZE 11 MOTOR GENERATOR

New size 11 Model 11GM152 operates between 6 and 200 v, 400 cps. No load speed is 6000 rpm with input of 3.5 watts at 0.053 amp. Output shafts to customer's specifica-

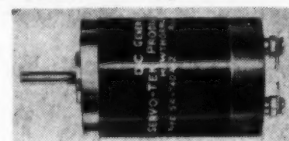


tion. Generator gradient is 0.5 v/1000 rpm and has a total null of 0.012 v. Ambient operating range is -65° to 200°C. Conforms to BuOrd Spec MIL-S-15087.—*Servo Dynamics Corp., Somersworth, N. H.*

For more information circle 102 on inquiry card.

DC TACHOMETER GENERATOR

New dc tachometer generator features guaranteed brushlife of 100,000 hours continuous operation at 3600

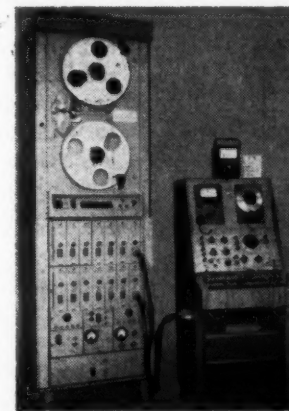


rpm. Linearity to 12,000 rpm is better than 0.1% of voltage output at 3600 rpm. Special brush materials and high-silver alloy commutator are used.—*Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J.*

For more information circle 103 on inquiry card.

MAGNETIC-TAPE TESTER

New completely-integrated Data-Tape Type 23-203 Test Set comprises a group of high-quality basic test instruments principally to carry out fast accurate adjustments and meas-

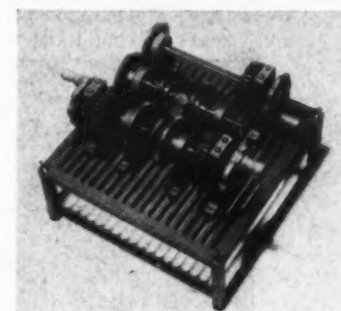


urements on the 5-752 Magnetic-Tape Recorder/Reproducer, but is also suited for use in aircraft flight lines, production lines, wind tunnels, test stands, or at any location where on-the-spot checkout of electronic equipment is desired.—*DataTape Div., Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif.*

For more information circle 104 on inquiry card.

MINIATURE COMPONENTS

New complete line of precision miniature breadboard components includes precision cast and ground breadboard plates, shaft hangers,

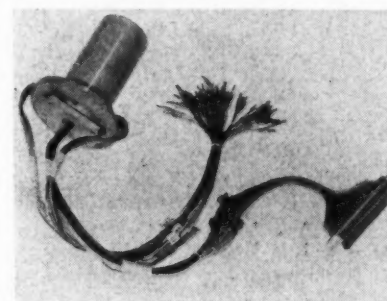


shaft collars, shim spacers and gears in the fine pitch series (96, 120 and 200 pitch) with delivery from stock. Catalog on request.—*PIC Design Corp., Sub. of Benrus Watch Co., Inc., 477 Atlantic Ave., E. Rockaway, L. I., N. Y.*

For more information circle 105 on inquiry card.

SLIP RING ASSEMBLIES

New low-torque, low-noise slipring and brush assembly (40 rings, 80 brushes) typical of large-scale production capabilities, tested less than 2 mv noise with all circuits in series and operated 1000 hrs at 500 rpm under -65°F to 300°F extremes.

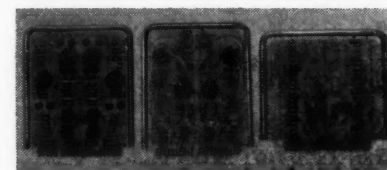


Breakaway friction under 75 gm-cm. Brochure on request.—*Slip Ring Co. of America, 5456 W. Washington Blvd., Los Angeles 16, Calif.*

For more information circle 106 on inquiry card.

DIGITAL COMPONENTS

New set of basic transistorized digital computer circuit packages includes flip-flops, diode logic boards, read amplifiers, write amplifiers, and



blocking oscillators. Each component board contains two identical circuits except the logic board, which contains 2-1, 2-2, 2-3, 1-4, 2-5 function "and" gates, and nine "or" gates.—*Aeronutronic Systems, Inc., Computer Div., Box MM-486, Newport Beach, Calif.*

For more information circle 107 on inquiry card.

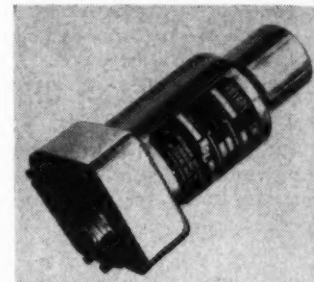
100-SECOND PROGRAMMER

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For more information circle 108 on inquiry card.

PAM TELEMTRY COMMUTATOR

Three-pole motor-driven telemetry commutator for PAM systems is adaptable to either airborne or ground gating. Each of three poles contains

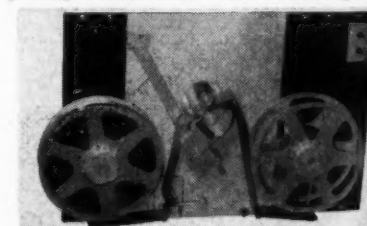


a flexible master pulse plus 28 BBM contacts. Meets 20G vibration and 50G shock tests, has guaranteed life of 500 hrs. Ungoverned 28 v dc motor is noise filtered, rotates switch at 10 rps through IDL reducing gears. Hermetically sealed.—*Instrument Development Labs., Inc., 67 Mechanic St., Attleboro, Mass.*

For more information circle 109 on inquiry card.

DATA TAPE TRANSPORT

New Hare 460 Series tape-synchronous transports allow exact reply of tapes from missiles having no tape-speed control, requiring only that recorded tape have a fixed frequency reference. Fast acting non-



resonant reel servo system permits even 0.5 mil tape to be handled without damage. Model 460A has standard speeds of 7.5, 15, 30 and 60 ips, with 2 ms start-stop, it also can be furnished to operate synchronously at any speed between 3.75 and 120 ips, using 1/4" to 1" tape. Model 461 for shipboard installation with front access, accommodates up to 2" tapes, has start-stop time of 30 ms.—*Spec. Apparatus Sales, Sangamo Electric Co., Springfield, Ill.*

For more information circle 110 on inquiry card.

MILITARY SYSTEMS DESIGN

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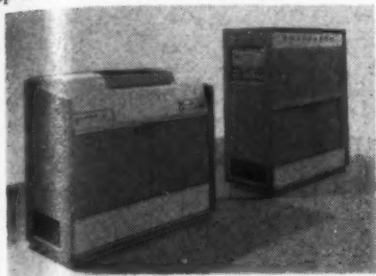
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DESIGN

HIGH-SPEED LINE PRINTER

New solid-state Line Printer will select, edit and print out data from a computer or magnetic tape at rates up to 1500 lines/min. Integrated with



the new Burroughs 220 electronic data processing system, it features on-line or off-line operation, buffer data storage and automatic editing—all under plugboard control.—Burroughs Corp., ElectroData Div., 460 Sierra Madre Villa, Pasadena, Calif. For more information circle 111 on inquiry card.

FM/FM TELEMETERING QUANTIZER

New Vernitel technique, consisting of quantizer and differential amplifier, continuously separates input voltages into 16 discrete levels and provides a residue voltage representing the analog scale between two quantized increments. Each voltage con-

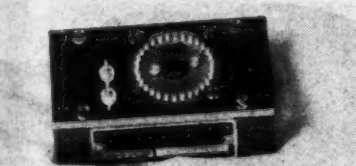


trols a standard FM/FM subcarrier oscillator to provide accuracy of $\pm 0.2\%$ on telemetry systems having a maximum error of $\pm 3\%$. Detailed description on request.—Hoover Electronics Co., 110 W. Timonium Rd., Timonium, Md.

For more information circle 112 on inquiry card.

SPRING-DRIVEN COMMUTATOR

New ASCOP Command Commutator is a spring-driven rotary sampling switch which makes one complete sampling cycle for each command received. Hand-wound spring



motor provides 100 or more sampling revolutions at $\frac{1}{2}$ or $\frac{1}{50}$ sec per revolution, being released by pulse signal into a solenoid actuator. Pulse can be from standard voltage source or discharge of capacitor.—Applied Science Corporation of Princeton, P.O. Box 44, Princeton, N. J.

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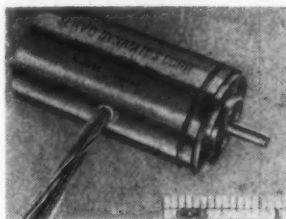
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SIZE 11 MOTOR GENERATOR

New size 11 Model 11GM152 operates between 6 and 200 v, 400 cps. No load speed is 6000 rpm with input of 3.5 watts at 0.053 amp. Output shafts to customer's specifica-

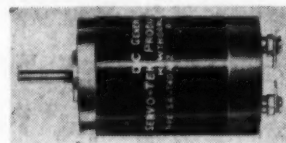


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For more information circle 102 on inquiry card.

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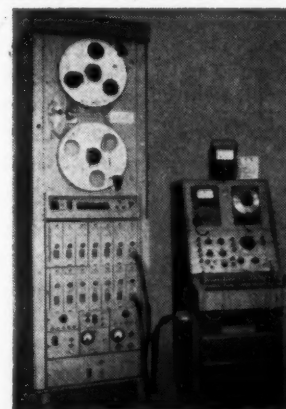


rpm. Linearity to 12,000 rpm is better than 0.1% of voltage output at 3600 rpm. Special brush materials and high-silver alloy commutator are used.—*Servo-Tek Products Co.*, 1086 Goffle Rd., Hawthorne, N. J.

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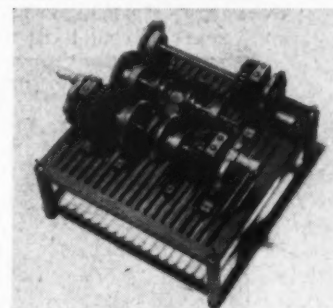


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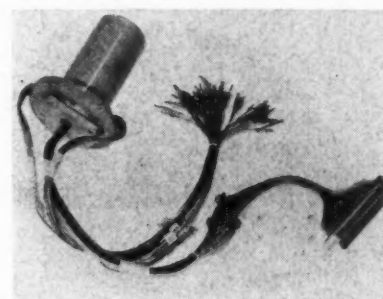


shaft collars, shim spacers and gears in the fine pitch series (96, 120 and 200 pitch) with delivery from stock. Catalog on request.—*PIC Design Corp.*, Sub. of Benrus Watch Co., Inc., 477 Atlantic Ave., E. Rockaway, L. I., N. Y.

For more information circle 105 on inquiry card.

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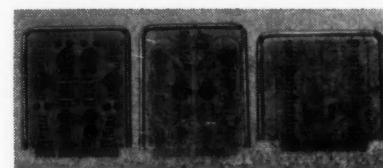


Breakaway friction under 75 gm-cm. Brochure on request.—*Slip Ring Co. of America*, 5456 W. Washington Blvd., Los Angeles 16, Calif.

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For more information circle 107 on inquiry card.

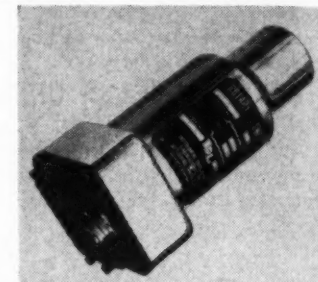
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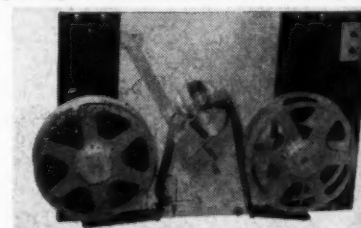


a flexible master pulse plus 28 BBM contacts. Meets 20G vibration and 50G shock tests, has guaranteed life of 500 hrs. Ungoverned 28 v dc motor is noise filtered, rotates switch at 10 rps through IDL reducing gears. Hermetically sealed.—*Instrument Development Labs., Inc.*, 67 Mechanic St., Attleboro, Mass.

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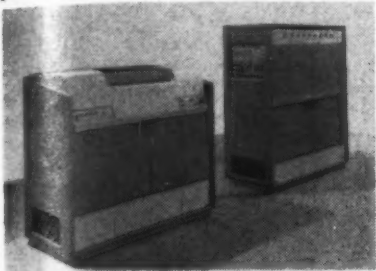
resonant reel servo system permits even 0.5 mil tape to be handled without damage. Model 460A has standard speeds of 7.5, 15, 30 and 60 ips, with 2 ms start-stop, it also can be furnished to operate synchronously at any speed between 3.75 and 120 ips, using 1/4" to 1" tape. Model 461, for shipboard installation with front access, accommodates up to 2" tapes, has start-stop time of 30 ms.—*Spec. Apparatus Sales, Sangamo Electric Co.*, Springfield, Ill.

For more information circle 110 on inquiry card.

MILITARY SYSTEMS DESIGN

HIGH-SPEED LINE PRINTER

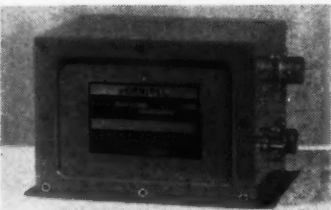
New solid-state Line Printer will select, edit and print out data from a computer or magnetic tape at rates up to 1500 lines/min. Integrated with



the new Burroughs 220 electronic data processing system, it features on-line or off-line operation, buffer data storage and automatic editing—all under plugboard control.—Burroughs Corp., ElectroData Div., 460 Sierra Madre Villa, Pasadena, Calif. For more information circle 111 on inquiry card.

FM/FM TELEMETERING QUANTIZER

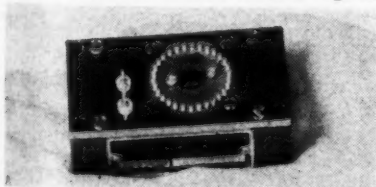
New Vernitel technique, consisting of quantizer and differential amplifier, continuously separates input voltages into 16 discrete levels and provides a residue voltage representing the analog scale between two quantized increments. Each voltage con-



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For more information circle 27 on inquiry card.

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Control Amplifier Modifies Gain Near Setpoint

A novel circuit being used in temperature controls for military aircraft, but also applicable in position servos, indicator systems, or anywhere a contact controller can be used, automatically adjusts the control loop gain to meet the changing requirements of the system.

When the conditions are far from setpoint the control acts as an ordinary contactor controller with a wide deadband, allowing the use of fast-acting actuators with no loss in stability. This region is the

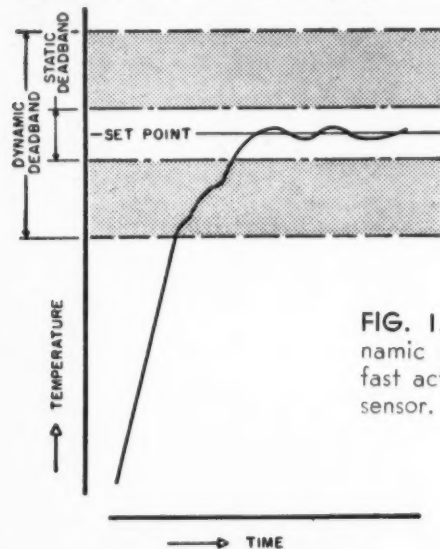


FIG. 1. TYPICAL dynamic response with fast actuator and slow sensor.

"dynamic deadband" shown in Fig. 1. When the conditions come within the "dynamic deadband" the Varigain circuit shuts off the controlled actuator; and, after a period corresponding to the inertial or inductive lag of the actuator compares the actual conditions with the set point.

If the conditions are not within the much narrower "static deadband" the Varigain circuit causes the actuator to operate intermittently until the conditions are at the set point. This produces the effect of a slower actuator operating stably within a narrow deadband.

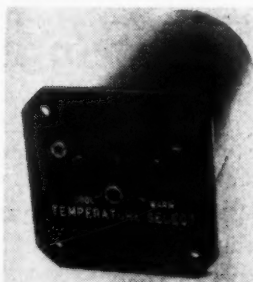


FIG. 2. VARIGAIN Control Amplifier combines transistors and relays in phase-sensitive controller.

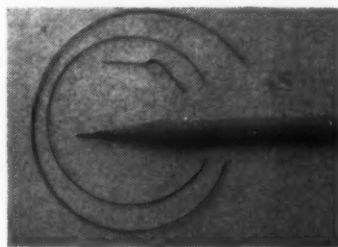
The Varigain Control Amplifier (Fig. 2), a product of Parameters, Inc., 195 Herricks Rd., New Hyde Park, N. Y., combines a stable silicon transistor amplifier with rugged relays in a high gain phase-sensitive contactor-controller which amplifies a threshold 1 mv signal into an output of 115v at 2 amps max. This controller has been used to control temperatures within 0.1°C but has many other applications.

For more information circle 114 on inquiry card.

New Products—CONT.

SHEATHED SUBMINIATURE THERMOCOUPLES

New metal-clad and ceramic-insulated Subminiature Thermocouples are rugged and resist corrosion, abrasion and erosion. They are made in

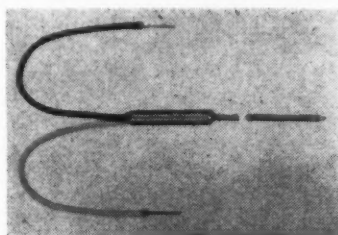


sizes from 0.020" OD, 2-wire; to 0.040" OD, 2-wire; and are available from stock in several sheath materials and most conductor combinations.—8-page Catalog PN10 furnishes details.—Pyro Electric, Inc., Dept. 30, P. O. Box 232, Barrington, Ill.

For more information circle 115 on inquiry card.

SPECIAL THERMOCOUPLES

New Con-P-Pak Thermocouples are designed to meet the severe demands required of controls and instruments used in rocket engines, melting furnaces, nuclear reactors; and in the

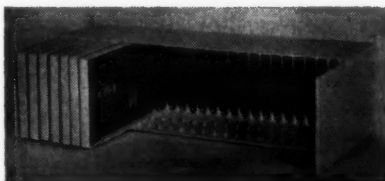


processing of liquid hydrogen, fatty acids, alcohols and other materials difficult to handle. Copper-Constantan is used for temperatures down to -300°F and Rh-Pt for temperatures over 1600°F. Conductors are encased in specially-processed ceramics and surrounded by chemically clean metal sheaths.—Data Sheet B contains details.—Continental Sensing, Inc., 1950 N. Ruby St., Melrose Park, Ill.

For more information circle 116 on inquiry card.

DIGITAL BUILDING BLOCKS

New transistorized Digital Systems Building Blocks for both high and low frequency have compatible signals,

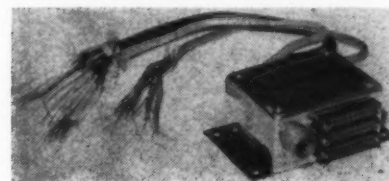


thus permitting both type units in one system. High frequency units will operate at any frequency up to 5 megacycles.—Digital Equipment Corp., Maynard, Mass.

For more information circle 117 on inquiry card.

THERMOCOUPLE REFERENCE

New miniature multichannel heated thermocouple reference junction replaces conventional ice bath and eliminates cold-junction compensators for

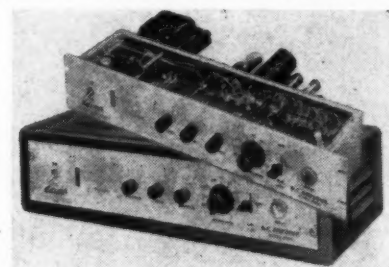


airborne and test cell uses. Reference temperature held to $\pm \frac{1}{2}^\circ\text{F}$, warm-up time is $\frac{1}{2}$ hr at 65°F and unit is encapsulated in heat resistant compound for minimum thermal effect on adjacent equipment. Uses under 50 watts, 28v ac or dc. Meets MIL-E-5272A.—Aero Research Inst. Co., 315 N. Aberdeen St., Chicago 7, Ill.

For more information circle 118 on inquiry card.

OSCILLOGRAPH AMPLIFIERS

New B-Series Amplifiers for oscillograph recorders drift less than 0.5 mv equivalent input per hour and operate from 115-v ± 5 v power lines.

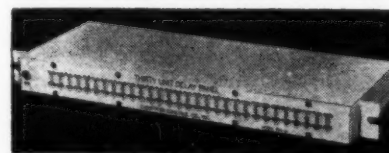


Two-meg input impedance plus optional zero suppression allow unit to be used with wide variety of transducers. Plug-in frequency compensation extends range of galvanometer to 200 cycles. Output connections are at rear, while inputs are both front and rear.—Edin, A Div. of Epsco, Inc., 207 Main St. Worcester 8, Mass.

For more information circle 119 on inquiry card.

COMPACT DELAY CHASSIS

New 30-unit delay chassis, Model DU-10, contains 30 separate electrical 1-μsec independent delay lines pack-



aged in a standard 19" x 1 1/4" rack-mounting chassis. Lines can be used separately or connected in series to form desired total delay. Upper cut-off is 5.6 mc; characteristic impedance is 91 ohms, with 1 db/μsec attenuation.—Computer Control Co., 92 Broad St., Wellesley, Mass.

For more information circle 120 on inquiry card.

PRESSURE TRANSDUCER

New Pressure Transducer PT-2 measures small pressure differentials

of 0-10 cm W.C. Pressure drop is applied across thin metal diaphragm to which is fastened the core of a differential transformer. Rugged ensemble is not easily damaged by rough handling. Sensitivity is 0.73 mv/mm W.C. with 5 v input at 4000 cps. Hysteresis is 0.856% with ± 10 cm W.C. pressure for 30 sec. Power supply can be any sinusoidal oscillator with 3 to 5 v rms output across an impedance of 200 ohms at 4000 cps frequency range, including 400 to 20,000 cps.—Custom Engineering & Development Co., 1429 South Ewing, St. Louis 4, Mo.

For more information circle 121 on inquiry card.

SPICE DIGITAL TAPE IN 2 SECONDS

Now splice all 3 to 8 channel paper tapes as well as all 1/2" to 1 1/4" mylar or acetate base magnetic tapes perfectly in TWO SECONDS with the miracle Presto-Splicer.

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For more information circle 28 on inquiry card.

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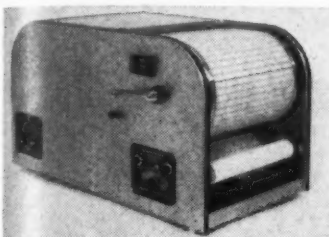
REPUBLIC Lens Co., Inc.
31 E. 169th ST., NEW YORK 52, N.Y.
CYpress 3-2790

For more information circle 29 on inquiry card.

MILITARY SYSTEMS DESIGN

OSCILLOGRAM PROCESSOR

New portable Model 23-109A Oscillogram Processor consists of a sealed thermistor sensing unit and a transistorized control amplifier in elec-



trical compartment. Provides close control of drum temperature. Includes a unitized drive assembly, speed-control contact shoe wide enough to allow simultaneous processing of two narrow rolls, and a take-up spindle coated with Teflon.—Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif.

For more information circle 122 on inquiry card.

VIEWING OSCILLOSCOPE

New Model 140 Oscilloscope, a low-cost rack-mounted viewing 'scope is for application to analog computers, characteristic tracers, etc. Supplied

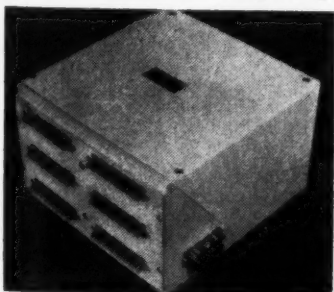


with identical horizontal and vertical amplifiers with sensitivities of 20 mv/in and response from dc to 50 kcs, it has a flat-faced tube to reduce reading error. No internal sweep is provided.—American Electronic Labs. Inc., 121 North 7th St., Phila. 6, Pa.

For more information circle 123 on inquiry card.

MULTICHANNEL SAMPLING SWITCH

New Model 108A high-speed sampling switch for sequential drift stabilization of up to 83 high gain dc amplifiers is made in compact plug-



in form, approx 10"x10"x6." 110v 60 cps motor drives switch rotor at 3 rps. Other technical data on request.—General Devices, Inc., Box 253, Princeton, N. J.

For more information circle 124 on inquiry card.

Circle 30 on inquiry card. →

Fallen Barriers...

"SOLAR" BLIND MULTIPLIER PHOTOTUBES from

PHOTOSENSITIVE DEVICES DEPARTMENT

Several photocathodes have been designed to fill the need for high ultraviolet response to the presence of white light and are now available in a series of multiplier phototubes.

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CATHODE-RAY TUBE ENGINEERING DEPARTMENT

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STORAGE TUBE ENGINEERING DEPARTMENT

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Flowsoldering in Automatic Production of Printed Circuits

In dip-soldering, the circuit panel must be lowered down to the molten solder (Fig. 1). In the "Flow-solder" technique, the solder is raised up to the circuit panel by an impeller pump, which forces the metal upwards through an elongated nozzle to form a stationary wave (Fig. 2). This wave of molten metal solders the joints between component leads and copper conductors on the underside of the panel.

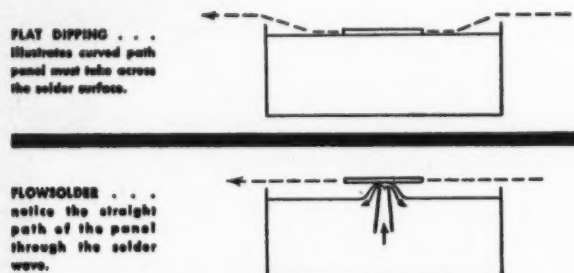


FIG. 1. STRAIGHT LINE motion of printed circuit panel facilitates automation of production.

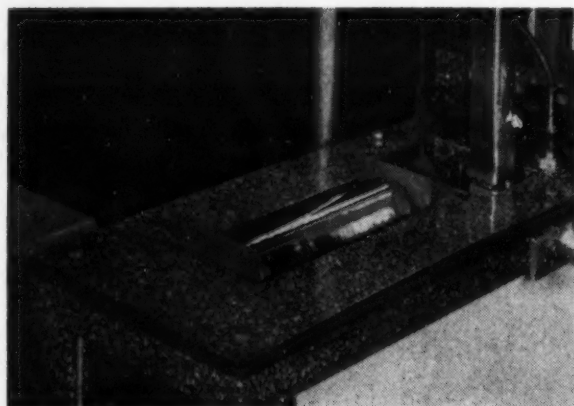


FIG. 2. SOLDER WAVE provides hot, clean solder flow with no entrapped air, easily regulated soldering level.

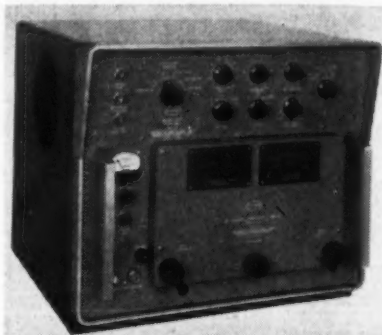
Advantages of "Flowsolder" over conventional dip-soldering in a static solder bath are: (a) Straightline motion of panel is simple to automate; (b) angled entry and exit needed to prevent air entrapment, are provided by shape of solder wave, eliminates double-dipping; (c) flow of hot solder is not chilled by cold panel and flux evaporation as in static bath; (d) clean solder flow eliminates skimming of both or use of anti-oxidants, necessary with static baths; (e) overheating and warping of panel from all-surface contact with solder is prevented with only a strip of panel in contact at any one time; (f) there is no limitation on length of panels and widths up to 9½" can be handled; (g) height of solder wave is easily regulated by speed of pump. (From 36-page manual, Fry's "Flowsolder" Method of Soldering Printed Circuits, Electrovert, Inc., 124 E. 40th St., New York 17, N. Y.)

For this literature circle 125 on inquiry card.

New Products—CONT.

MICROWAVE SIGNAL GENERATOR

New Model PMX test instrument generates internal pulse, square wave or FM signals 4,450 to 11,000 mc range with two plug-in tuning units.

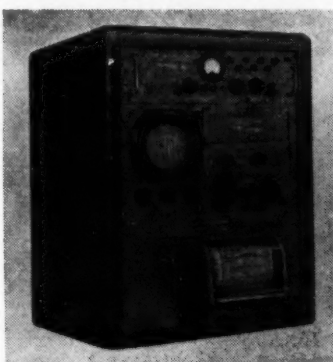


Its range of internal pulse capabilities include 0.2–10 μ sec variable width; 2–2,000 μ sec delay; and 10–10,000 pps rep-rate. Pulse rise and decay time is 0.1 μ sec. Internal FM generation is a linear sawtooth with 5 mc frequency deviation. All signals can be synchronized externally with any pulse or sine wave; also generates delayed or undelayed pulses, negative or positive, for synchronizing other equipment.—*Polarad Electronics Corp., 43-20 34th St., Long Island City, N. Y.*

For more information circle 126 on inquiry card.

SPECTRUM & POWER DENSITY ANALYZER

New S-2 Panoramic instrumentation system consists of PDA-1 Spectral Power Density Analyzers plus Spectrum Analyzer and chart recorder. Covering both random and discrete data, repeatable records are

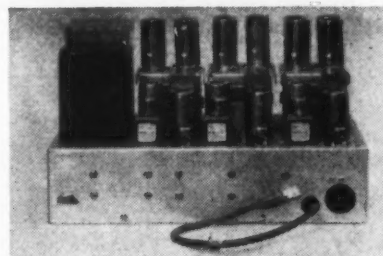


readily made in vibration and environmental tests, speech and noise analysis, medical and geophysical waveforms, Fourier analysis of periodic motions, and random waveform analysis (time stationary or otherwise). Frequencies from 0.5 to 300 kc are covered in three overlapping ranges. Detailed specification bulletin on request.—*Panoramic Radio Products, Inc., 520 S. Fulton Ave., Mt. Vernon, N. Y.*

For more information circle 127 on inquiry card.

MULTI-RANGE FREQUENCY GENERATOR

New self-contained Model T868 frequency generator incorporates tuning fork resonators and frequency dividing networks to supply accurate

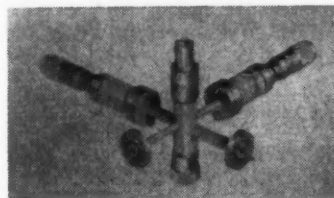


frequency reference to T806 turntable rate motor drive and other gyro test tables.—*Instrument Div., Sterling Precision Corp., 17 Matinecock Ave., Port Washington, N. Y.*

For more information circle 128 on inquiry card.

140 KMC EQUIPMENT

Equipment for generating, detecting and measuring micro-waves up to 140 kmc is designed to permit the use of working models only 1/10 actual size in engineering research. New line in-

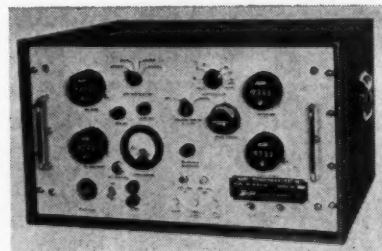


cludes crystal multipliers, crystal mounts, E-H tuners, wavemeters, SW detectors, phase shifters, attenuators, elbows, magic T's, and other waveguide components, available in continuous coverage from 2.6 to 140 kmc.—*De Mornay-Bonardi, 780 Arroyo Parkway, Pasadena, Calif.*

For more information circle 129 on inquiry card.

L-BAND TRANSPONDER TEST SET

New ATC transponder test set for shop and ramp testing of L-band airborne transponders manufactured to ARINC characteristics 532B and ANDB 2.3 NAIB, has double pulse



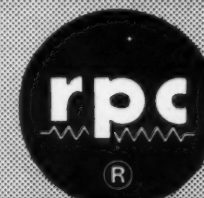
generator, strip transmission line directional couplers; signal generator; calibrated attenuators; power monitor and pulse spacing network.—*Micro-wave Div., Kearfott Co., 14844 Oxnard St., Van Nuys, Calif.*

For more information circle 130 on inquiry card.

METAL FILM RESISTORS



NEW! This precision low noise metal film resistor meets and exceeds requirements with temperature coefficient of plus or minus 50 ppm/°C independent of resistance value. Standard tolerance plus or minus 1 per cent. Type WHM-1.125" long x .406" diam.—is equivalent to MIL Style RN 75, maximum voltage rating 500V. Type WFH-.781" long x .250" diam.—equivalent to MIL Style RN 70, maximum voltage rating 350V. Enclosed in specially designed hermetically sealed plastic casing (patent pending) to protect precision resistor element.



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Specialists in manufacturing quality resistors: Precision Wire Wound — High Voltage — High Megohm — High Frequency. Our test equipment and standards for checking and calibrating are matched only by leading laboratories. Write for more information.

HIGH MEGOHM RESISTORS

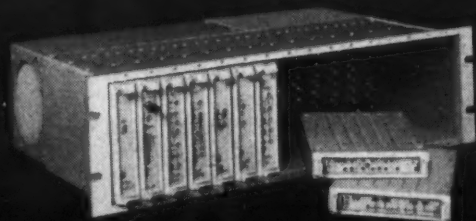
Type H. For electrometer circuits, radiation equipment and as high resistance standards. Resistance available to 100 million megohms. Voltage rating to 15,000 volts. Low temperature and voltage coefficient. Seven sizes, from ¾" to 3" long, of which 2 meet requirements of MIL-R-14293A. Standard resistance tolerance 10%. Tolerance of 5% and 3% available. Also matched pairs with 2% tolerance.



For more information circle 31 on inquiry card.

MILITARY SYSTEMS DESIGN

Harvey-Wells presents



**SPEED
ACCURACY
RELIABILITY**

5 mc Data Bloc • Data-Pac

... Data Bloc units are basic building blocks which can be reused any number of times ... compact design permits rapid assembly of shift registers, counters, pulse generators for digital logic and data handling systems ... later production runs made easy by compatible Data-Pac units ...

NMR instrumentation, electromagnets and power supplies, error signal comparator ... digital components.



HARVEY-WELLS ELECTRONICS, INC.

Research and Development Division

5168 WASHINGTON ST., W. ROXBURY 32, MASS.

For more information circle 32 on inquiry card.

DIGITAL TECHNIQUES FOR COMPUTATION AND CONTROL

by Martin L. Klein, Harry C. Morgan, Milton H. Aronson ... FIRST comprehensive survey of basic digital techniques ... includes basic principles, basic circuits, components and available commercial equipments ... Dynamic digital material thoroughly covered in 394 pages. Cloth bound with dust jacket, illustrated, 5 1/2" x 8 1/2" \$6.00

THE COMPUTER HANDBOOK

edited by M. H. Aronson. A clear introduction to the entire field of electronic computers and data processors. Presentations by computer manufacturers at the Second Computer Clinic. Paperbound, 72 pages, 1956. \$2.00

MECHANICAL MEASUREMENTS BY ELECTRICAL METHODS

by H. C. Roberts ... describes gaging methods based on variations of capacitance, inductance, resistance, as well as photoelectric piezoelectric, thermoelectric acoustic, and other methods ... covers principles of bridge and potentiometer circuits, plus required and available equipment. Second edition, cloth, 368 pages, 1951. \$2.00

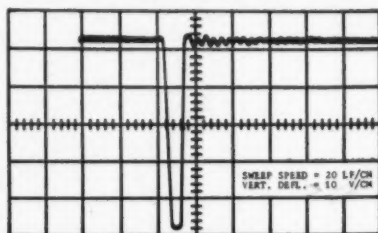
INSTRUMENTS PUBLISHING CO., INC.

845 RIDGE AVE., PITTSBURGH 12, PA.

January-February, 1959

ULTRA-SHORT PULSER

New Model 1051 Millimicrosecond current pulse generator for development work in research, computer design, and hi-speed transistor switch-



ing provides 2 amp pulses in 10, 20, 50 and 100 light-foot duration (1 LF is approx 1 milli- μ sec). Sync pulse precedes main pulse by 50 LF; either may be positive or negative. Typical 10 LF pulse across 50 ohm load is shown.—Rese Eng., Inc., 731 Arch St., Philadelphia 7, Pa.

For more information circle 131 on inquiry card.

RESEARCH PULSE GENERATOR

New Model B-7 Pulse Generator for research work on high-speed pulse circuitry provides rep-rates from 20 cps to 2 mc from internal oscillator,

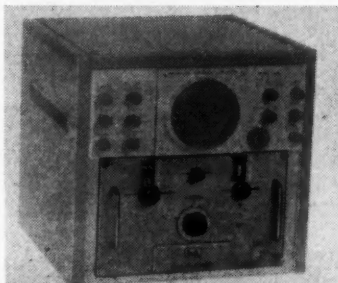


pulse widths from 0.05 to 10,000 μ sec, and delays from 0 to 10,000 μ sec. Can also be triggered externally; output pulse duty factor is 25%. Occupies 8-3/4" panel space or forms bench unit with end frames shown.—Rutherford Electronics Co., 8944 Lindblade St., Culver City, Calif.

For more information circle 132 on inquiry card.

X BAND ANALYZER HEAD

New Model 30X5 RF head covering the 8.5 to 9.7 kmc range of the X band is designed for use with the Itek SA30 Microwave Spectrum Analyzer. Direct-reading dial gives



frequency readings accurate to 0.05% or better; also has precision 80 db attenuator and tracked reflector voltage for constant display centering. Tech bulletins on request.—Itek Corp., 1568 Trapelo Rd., Waltham 54, Mass.

For more information circle 133 on inquiry card.

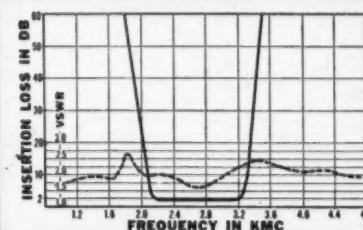
MC RF

Filters

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Continuously-Matched Filter Network — 50 Ohms resistive in the stopbands, VSWR 2.5:1 maximum near cutoff frequencies.

Similar low-, high-, and bandpass units are available from VHF through X-Band frequencies. Write for literature



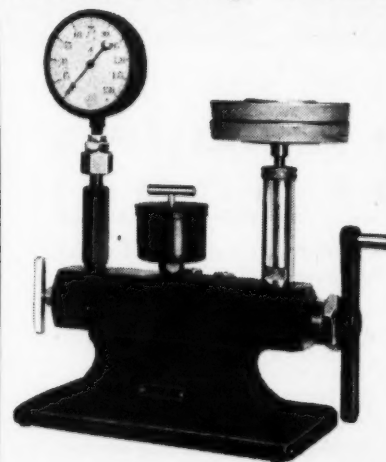
RF COAX and WAVEGUIDE FILTERS, standard or to fit your requirements
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For more information circle 33 on inquiry card.

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For more information circle 34 on inquiry card.

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FLIGHT TIME: 4 HOURS FUEL USED: NONE!

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Many Reflectone components and package systems, incorporating the engineering and manufacturing skill which produces the most intricate simulators, are now available to help solve other electronic and electro-mechanical design and application problems.

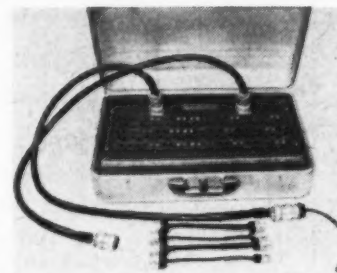
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SIMULATORS • COUPLINGS • PROCEDURE TRAINERS**



THE REFLECTONE CORPORATION • STAMFORD, CONNECTICUT
For more information circle 36 on inquiry card.

AIRCRAFT CIRCUIT ANALYZER

Analyzer leads are inserted between opened connectors of any aircraft circuit using Deutsch connectors, bringing the Analyzer into the circuit. SPST switches and series-



connected jacks then permit voltage, resistance and current measurements. Insulation leakage and signal characteristics can also be checked by appropriate meters or scopes. Models SI 3002-37 and SI 3002-61 have 37- and 61-circuit capacities respectively.—*Scott Instrument Co., 3734 W. Slauson Ave., Los Angeles 43, Calif.*
For more information circle 134 on inquiry card.

PRESSURE-TO-FREQUENCY TRANSDUCER

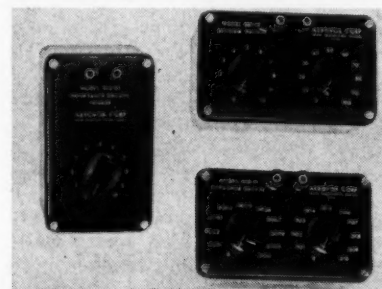
New ultra miniature OSCIDUCER, a temperature-stabilized silicon transistor oscillator combined with a variable inductance diaphragm-type pressure transducer, provides a complete



in-line instrumentation module for remote measurement of pressure. Requires only three connections: 28v at 2 ma dc, ground, and output. Oscillator and transducer may also be used separately. Available for all IRIG channels, technical data sheet on request.—*Solid State Electronics Co., 8158 Orion Ave., Van Nuys, Calif.*
For more information circle 135 on inquiry card.

DECADE BOXES

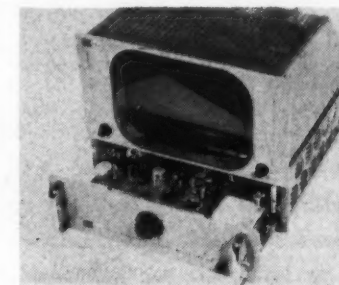
New line of Decade Boxes, comprising 3 capacitance models, 3 resistance models, and 4 inductance models;



has heavy duty construction for long, trouble-free operational life.—*Aerovox Corp., New Bedford, Mass.*
For more information circle 136 on inquiry card.

ITV

New Model 1986 System has built-in, fully automatic light-adjustment control which will instantly adjust to variations in light level of up to 1000:1. System consists of Model 1986C Camera, Model 1986ACU Cam-



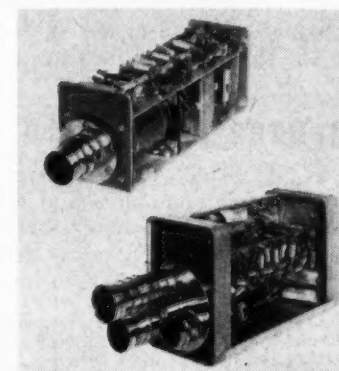
era Control Unit, and Model DRM-14R Monitor. The bandwidth of the video amplifiers is 8 megacycles, ± 0.5 db. A transistorized stable full count-down sync generator provides EIA standard pulses, either crystal-controlled, line-locked, or free-running.—*Cohu Electronics, Inc., Kin Tel Div., 5725 Kearny Villa Rd., San Diego 12, Calif.*
For more information circle 137 on inquiry card.

REMOTED ZOOM LENS

New Zoomar Mark II ITV lens in two focal length ranges mounts on any $\frac{5}{8}$ " Vidicon ITV camera. Has built-in motors for distance, zoom and iris control.—*Zoomar, Inc., Glen Cove, N. Y. & Hollywood, Calif.*
For more information circle 138 on inquiry card.

RUGGEDIZED ITV CAMERA

New TC-200-RT transistor-type ruggedized CC-TV Camera, and Type TC-200-RS with subminiature tubes, have modular design, and are constructed to permit maximum response in the presence of ambient noise in ex-

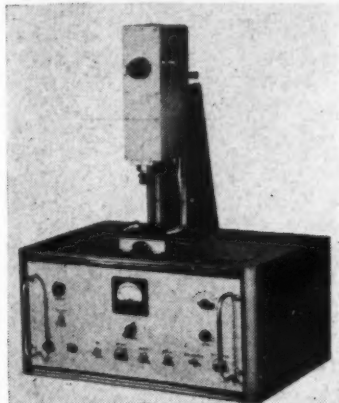


cess of 175 db. Either one will withstand vibration and shock of more than 0.06" displacement at 5 to 33 cycles and 20G in 3 axes. Temperature in excess of $+50^\circ$, 100 percent humidity, and operation at 100,000 ft altitude will not affect the picture quality. The vidicon camera, produces a high-resolution, 2:1 interlace TV signal.—*Allen B. Du Mont Labs., Inc., Industrial Television Sales Dept., 760 Bloomfield Ave., Clifton, N. J.*
For more information circle 139 on inquiry card.

MILITARY SYSTEMS DESIGN

SEMICONDUCTOR LIFETIME MEASUREMENT

New Semiconductor Lifetime Measuring Equipment uses a spark-gap type light source of 3 μ sec duration

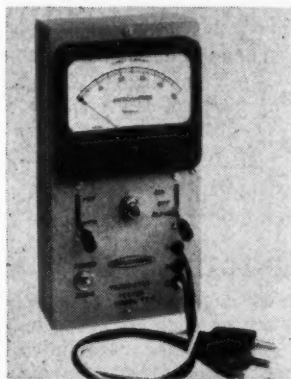


of such intensity that carriers in the order of $10^{13}/cc$ are injected into the semiconductor. Exceptionally useful in measuring minority carrier lifetime, drift mobility and photo-effects in semiconductors, it supplies external sync for triggering an external scope, on which decay of photoconductive current can be observed. Literature on request.—*Electro Impulse Lab., 208 River St., Red Bank, N. J.*

For more information circle 140 on inquiry card.

UNIVERSAL TRANSISTOR TESTER

New Model TT-1 tests low, medium and high-power type, PNP and NPN transistors. Leakage and gain characteristics and shorts are tested; also



reverse and forward current ratios of diodes. Provides 50 μ amp meter movement, with self-contained battery power, in sturdy case for portable use.—*The Reflectone Corp., Post Rd. and Myano Lane, Stamford, Conn.*

For more information circle 141 on inquiry card.

SINGLE-AXIS SIMULATION TABLE

New Model A916 Single-Action flight simulation table, used with an analog computer, function generator, tape recorder or digital-to-analog converter, can determine dynamic characteristics of high performance gyros and accelerometers, evaluate automatic pilot systems. Table is actuated

hydraulically with pistons controlled from a high-gain servo system which is said to provide resolution to ± 2.5

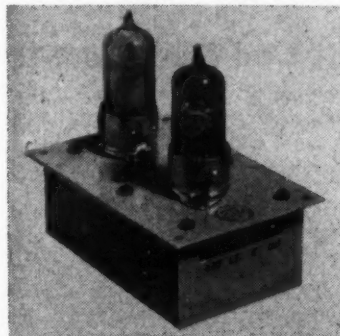


seconds of arc, amplitude flat within ± 2 db to 45 cps, and excellent reproducibility.—*Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.*

For more information circle 142 on inquiry card.

OVENLESS CRYSTAL OSCILLATOR

New crystal oscillator using no oven has stability of ± 5 ppm/ $^{\circ}C$ over the temperature range of $-20^{\circ}C$ to $70^{\circ}C$, requiring no warm-up time. Available for any frequency

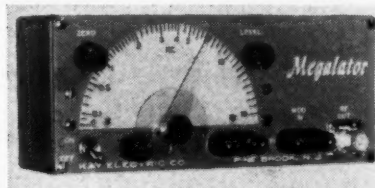


in the 4 to 16 mc range, the oscillator weighs only 9 oz and withstands acceleration to 10 G.—*Marconi Instruments, 111 Cedar Lane, Englewood, N. J.*

For more information circle 143 on inquiry card.

AMPLITUDE MODULATOR

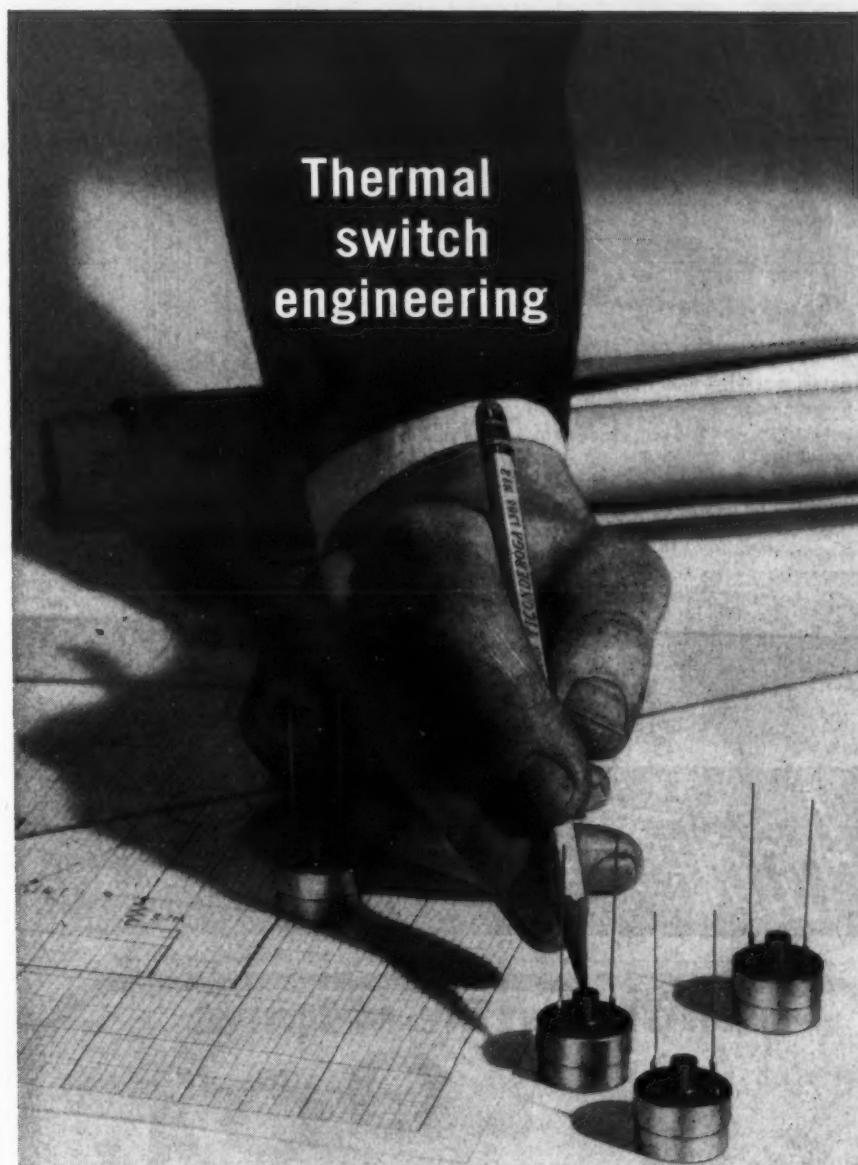
New battery-powered "Megalator" provides over 100% amplitude modulation over CW and FM frequency



ranges (dc to 1000 mc), and audio oscillations from 15 cps to 15 kc, also contains beat-frequency audio oscillator and output attenuator. Can be used with any sweeping oscillator or signal generator as a general purpose lab instrument.—*Kay Electric Co., Dept. 1A, Maple Ave., Pine Brook, N. J.*

For more information circle 144 on inquiry card.

Thermal switch engineering



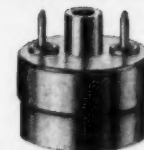
ANOTHER "CRITICAL" CONTROL SWITCH FROM CPI RESEARCH

If you are concerned with measurement of surface temperatures in aircraft and airborne electronic equipment in confined spaces, this may be a thermal switch you could use. We designed and manufactured it to meet exacting specifications of a prominent aircraft manufacturer.

Chances are your needs may require modifications or even a completely new switch. We have always realized that there are few "critical" control switches that can be all things to all people. That's why we have the research and development engineers who can and do tackle specific problems of thermal control. Can we help you solve yours?

This new hermetically sealed, bi-metal, single or 2-wire switch has calibration range of $-20^{\circ}F$ to $600^{\circ}F$; safe momentary overshoot to $800^{\circ}F$; available with various type mountings. When inquiring, mention "button" switch.

CPI



CONTROL PRODUCTS, INC.

311 Sussex Street, Harrison, N. J.

For more information circle 37 on inquiry card.

AUTOTRONICS for precision control



Model MCC

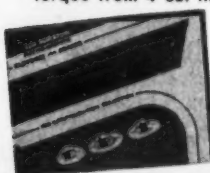
DUPLEX MINIATURE ELECTRO-MAGNETIC CLUTCH

DE-ENERGIZED—both flanges as well as the output shaft are free running.

ENERGIZED—either coil engages its respective flange to the output shaft.

The function of the shafts may be reversed so that a single input can be connected to either of two output shafts.

The model MCC is available in four sizes and two standard shaft configurations, pilot diameters from .500" to 1.250", torque from 4 oz. in. to 56 oz. in.

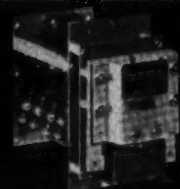


Write for catalog 957
for data on all Auto-
tronics standard clutch
and brake units.

AUTOTRONICS INC. Box 812, Rt. 1,
FLORISSANT, MISSOURI

For more information circle 38 on inquiry card.

HIGH ATMOSPHERE BALLOON CONTROL INSTRUMENTS require MAXIMUM Performance MINIMUM Size - Weight - Power Drain



TIMER—Model AGS-4
Number of circuits—4 SPDT
Weight—6.1 oz.
Speed reg.— $\pm 1.0\%$ @
50% voltage shift
Power input—.008 Amp. @
6 V.D.C.
ALSO AVAILABLE 1, 2 OR
3 CIRCUITS



MOTOR—Model TR
Transistor commutated
No RF interference
Lifetime of at least 3 years' continuous operation
Wide choice of speeds
Weight—2.5 oz.
Power input—.008 Amp. @
6 V.D.C.



TIMER—Model AGC
No. of decks—1-4
Segments per deck—2-12 for stock units. Special commutators to order at nominal tool charge.
Speed reg.— $\pm 1.0\%$ @ 50% voltage shift
Power input—.008 Amp. @ 6 V.D.C.

WRITE FOR LITERATURE
BRAILSFORD & CO. INC.
670 MILTON ROAD • RYE, N.Y.

ENGINEERING DEVELOPMENT
SUB FRACTIONAL WATT D.C. MOTORS



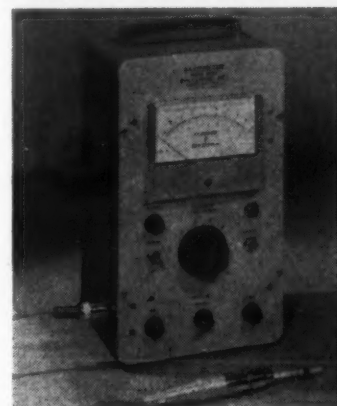
MANUFACTURING
SIGNALLING SYSTEM COMPONENT

For more information circle 39 on inquiry card.

New Products—CONT.

TRANSISTORIZED GAUSSMETER

New Model D-855 Gaussmeter, designed for accurate flux measurement up to 30,000 gauss, gives steady accurate indication without ballistic

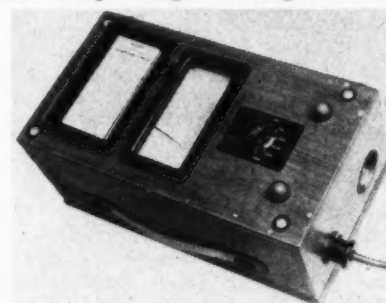


jerk, also "flow" direction. Can be equipped to measure earth field density; internal battery provision adapts it for field use. Probe is 0.025" thick with active area of 0.01 sq in.—*Dyna-Empire, Inc., 1075 Stewart Ave., Garden City, N. Y.*

For more information circle 145 on inquiry card.

STEP-VOLTAGE MEGGER

New rectifier-operated Megger insulation testing meter is designed for new step-voltage testing methods



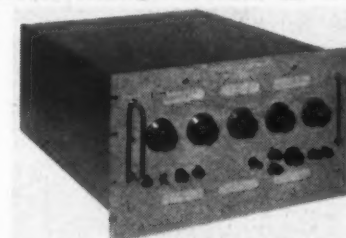
which involve sequential application of two or more dc test voltages and critical observation of any reduction of insulation resistance at the higher voltage. New instrument has 6 output voltages: 500, 750, 1000, 1500, 2000, and 2500, with a range of 0-10,000 megohms on a single easily read scale. Bulletin 21-20a, describing step-voltage testing, is available on request.—*James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.*

For more information circle 146 on inquiry card.

PRECISION CURRENT GOVERNOR

A programmable constant current source of high accuracy and stability required for meter calibration, gyro torque measurements, and measurements of zener diodes, transistors, pots, bolometers, thermistors, magnetic cores, and other current-sensitive devices. Models CS-11 Current Governor furnishes from 1 μ a to 100

ma in steps of 1 μ a at load voltages from 0 to 50 v. Accuracy at any current setting is $0.02\% \pm 0.1 \mu$ a,

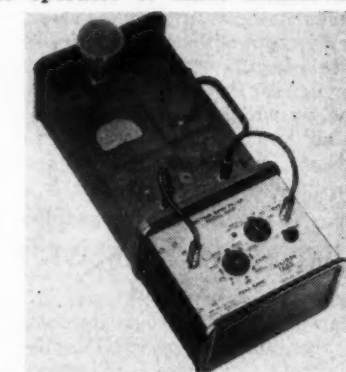


with line regulation better than 0.0005%.—*North Hills Electric Co., Inc., 402 Sagamore Ave., Mineola, L. I., N. Y.*

For more information circle 147 on inquiry card.

OCTAVE BAND FILTER SET

New Model 530P Octave Band Filter Set, when attached to the GRI551A Sound Level Meter, allows the operator to make measurements

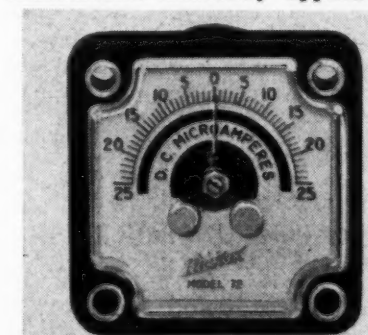


in octave bands. The bands consist of: 20-75, 75-150, 150-300, 300-600, 600-1200, 1200-2400, 2400-4800, and 4800-10,000 cps. A built-in transistorized amplifier allows for measurement of noise in these bands to more than 36 db below the overall noise level.—*Allison Labs., 14185 Skyline Dr., La Puente, Calif.*

For more information circle 148 on inquiry card.

LONG-SCALE SUB-MIN METER

New ruggedized subminiaturized panel meter has 180° arc-scale 1.52" long, enabling accurate indications in miniaturized military applications.



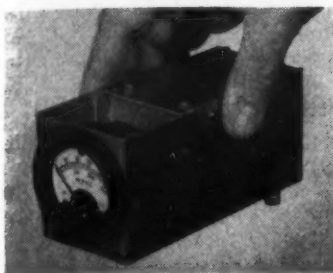
Meets all applicable requirements of MIL-M-10304A; available in standard dc, ac-rectifier ranges.—*The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio*

For more information circle 149 on inquiry card.

MILITARY SYSTEMS DESIGN

MINIATURE VTVM

New Model SPD-25, smallest self-contained electronic voltmeter, meets MIL-T-945A for use in aircraft, missiles and ground support use. Oper-

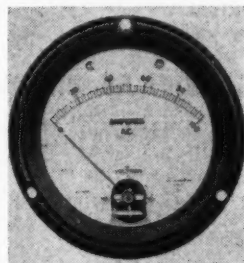


ates on 115 v, 400 cps, is available in any range from 0-30 mv to 0-300 v. Frequency response is 40 cps to 50 kc; input impedance is 1 megohm, 15 μ f; stability with 10% line voltage change is better than 2%. Voltmeter accuracy is $\pm 3\%$.—Metronix, Inc., Chesterland, Ohio

For more information circle 150 on inquiry card.

LINEAR AC AMMETER

New ac ammeter which has 2% accuracy at any part of the scale over the frequency range from 300 to 2000



cps and from -55° to 71°C uses external current transformer for currents over 10 amperes. Movement operates on 5 ma full scale, withstands 1000% overload for 5 sec. Hermetically sealed styles meeting MIL-M-10304A are $2\frac{1}{2}$ ", $3\frac{1}{2}$ " and $4\frac{1}{2}$ " round.—Voltron Products, 1010 Mission St., S. Pasadena, Calif.

For more information circle 151 on inquiry card.

SOUND-LEVEL METER

New Type 1551-B Sound-Level Meter includes many new technical features and improvements over its



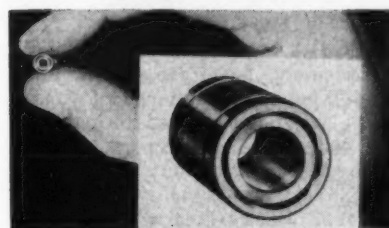
predecessors, such as new microphone, meter circuit, calibration circuit for amplifier gain standardization and

adjustment for microphone sensitivity; and improved signal-to-noise ratio and dynamic range, and frequency response.—"The Experimenter," Vol. 32, No. 17, contains details.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

For more information circle 152 on inquiry card.

MINIATURE BALL BUSHINGS

New INST-258 and INST-396 ball bushings eliminate friction in linear motion bearings in military inertial and control uses for shafts 0.1246" and

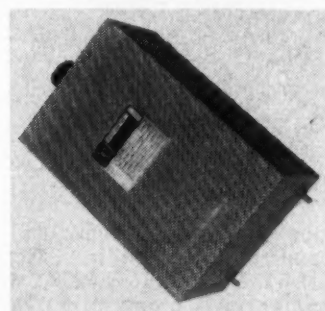


0.1871" dia. Each bushing has 3 circuits precision milled steel balls, outer steel sleeve and brass ball retainer. Tech data on request.—Thomson Industries, Inc., Manhasset, N. Y.

For more information circle 153 on inquiry card.

TRANSISTORIZED CONVERTER

New Model PS6001 frequency converter, meeting MIL-Specs for Ground equipment, provides 250 watts square



wave, 115 v 400 cps output from input of 120 v, 60 cps. Operates at any temperature between -30° and 52°C ; it is not damaged by excursions to -65° or 85°C .—Power Sources, Inc., Burlington, Mass.

For more information circle 154 on inquiry card.

SUB-MIN COAXIAL CONNECTORS

New line of 50-ohm connectors for sub-miniature coax cable can be readily worked in field with small wrench or pliers, due to hexagonal body and



nut shapes. New sealing method gives high pull-out strength without deforming cable dielectric.—Sealectro Corp., 610 Fayette Ave., Mamaroneck, N. Y.

For more information circle 155 on inquiry card.

TRANS-SONICS

LARGEST MANUFACTURER OF TRANSDUCERS FOR TELEMETERING

Introduces

TYPE 78 PRESSURE POTENTIOMETERS FOR TELEMETERING AND CONTROL APPLICATIONS



- COMPACT — LIGHT — ONLY 6 OUNCES
- OUTSTANDING ENVIRONMENTAL PERFORMANCE
- HERMETICALLY SEALED MECHANISM
- STAINLESS STEEL CONSTRUCTION

Type 78 Pressure Potentiometers feature accurate and reliable performance under severe environmental conditions:

Sinusoidal Vibration: 1" da, 2 to 22 cps; 25 g, 22 to 2000 cps

Random Gaussian Vibration: 0.1 g^2/cps , 15 to 2000 cps

Sustained Acceleration: 50 g on any axis

Mechanical Shock: 30 g on any axis

Operating Temperature: -65°F to $+160^{\circ}\text{F}$ with minimum change in output

Hermetic sealing protects entire mechanism against sand and dust, humidity, salt spray, fungus, and the fluid being measured. Unit has welded stainless-steel case, is $1\frac{1}{8}$ " diameter by $1\frac{1}{8}$ " long, weighs only 6 ounces. Standard ranges are 0-15, 0-25, and 0-50 psia; other ranges available.

Write to Trans-Sonics, Inc., Dept. 12, Burlington, Mass., for further information on Type 78 Pressure Potentiometers.

TRANS-SONICS

Precision Transducers

For more information circle 40 on inquiry card.

CHART-PAK precision tapes and die-cut symbols made these conductor paths and terminal pads for a printed circuit layout in 9 minutes 40 seconds!

HOW LONG WOULD IT TAKE YOU TO DRAW THEM?

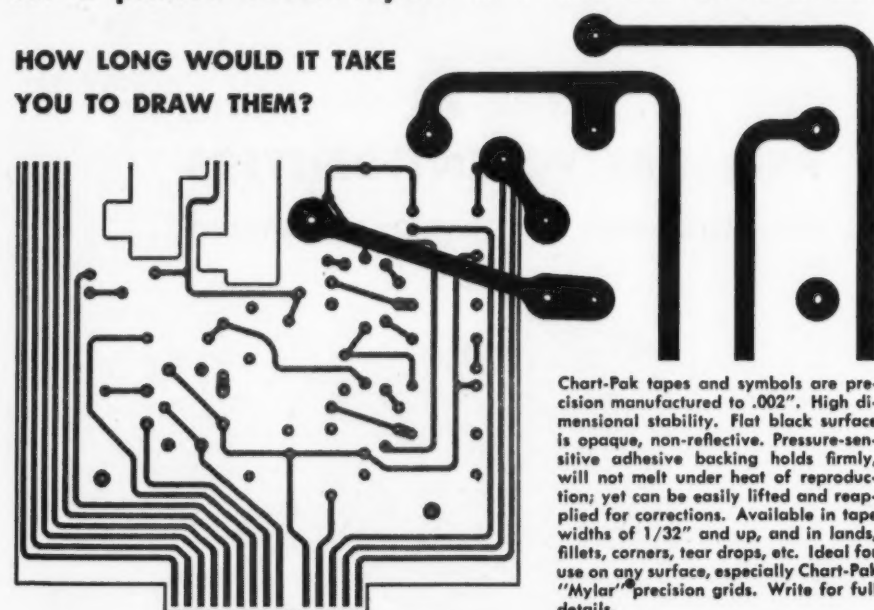


Chart-Pak tapes and symbols are precision manufactured to .002". High dimensional stability. Flat black surface is opaque, non-reflective. Pressure-sensitive adhesive backing holds firmly, will not melt under heat of reproduction; yet can be easily lifted and reapplied for corrections. Available in tape widths of 1/32" and up, and in lands, fillets, corners, tear drops, etc. Ideal for use on any surface, especially Chart-Pak "Mylar" precision grids. Write for full details.

CHART-PAK
Saves time...
Saves money!



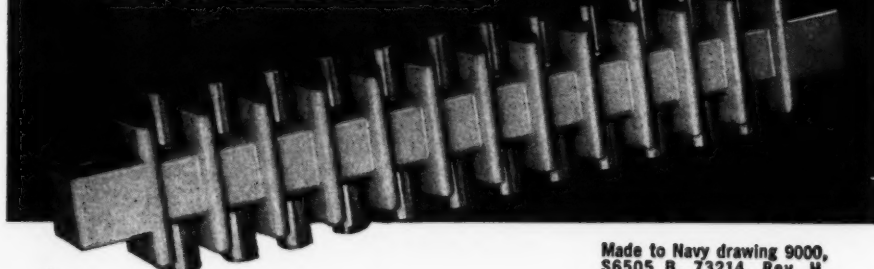
CHART-PAK, INC.

ORIGINATOR OF THE TAPE METHOD OF DRAFTING

202 River Road, Leeds, Mass.

For more information circle 41 on inquiry card.

NAVY TERMINAL BOARDS



Made to Navy drawing 9000,
S6505 B, 73214, Rev. H.

Designed by the Bureau of Ships and covered by applicable MIL specs, these boards or blocks are ideal for other heavy-duty assemblies and services. Available in several different lengths and number of terminals. Supplied in MAI-60 glass-filled Alkyd as per MIL-M-14 with latest revision. Threaded studs of manganese-bronze, molded in plastic. Slotted brass nuts. Other Navy types also available.

WRITE FOR LITERATURE . . .

Latest Kulka Terminal Block Catalog sent on request. Let us have your terminal block problems and requirements. Our specialty!

KULKA ELECTRIC CORP.

633-643 So. Fulton Avenue
Mount Vernon, N. Y.

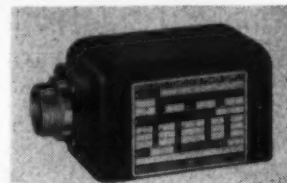
KULKA

For more information circle 42 on inquiry card.

New Products—CONT.

GYRO DRIVE POWER INVERTER

New transistorized power inverter Model 591-J supplies 40 va, 400 cps sine-wave output for maximum non-heating performance from ac gyros

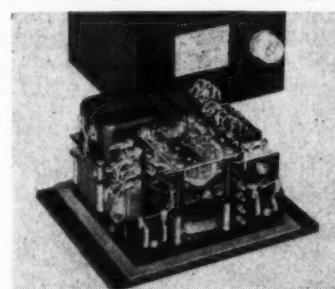


and motors. Anti-hunt circuit eliminates tendency of ac gyro spin motors to undershoot or overshoot near synchronous speed by controlling frequency independent of gyro reactance variations. Nominal input voltage 24, 26 or 28 v dc.—*Arnold Magnetics Corp., 4613 W. Jefferson Blvd., Los Angeles, Calif.*

For more information circle 154 on inquiry card.

STABILIZED STATIC INVERTER

New solid-state inverter transistor and magnetic amplifier circuits to provide 80 va power at 115 v, 400 cps (stable within $\pm 1\%$) from 18 to 30 v dc input. Output voltage may

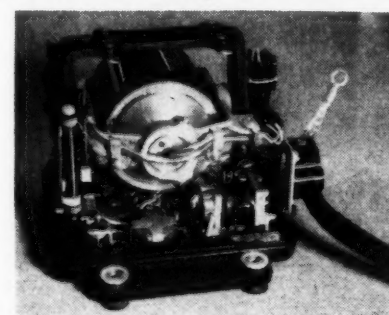


be manually adjusted from 105 to 125 v, and frequency within ± 3 cps. Meets Mil-E-5400 and E-5272, will withstand variable inputs to 40 volts and will not spark at any altitude.—*Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.*

For more information circle 157 on inquiry card.

RATE GYRO

New Model GG79 can be furnished with one or two potentiometers, with rate switch, for operating at a predetermined turning rate. Also incor-



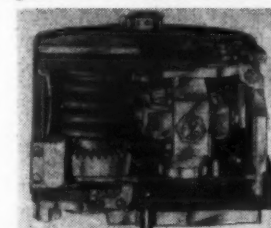
porates advanced damper and other features for operation in rugged environments. Ambient temperature

range -65° to 165°F ; potentiometer resistances range from 420 to 15,000 ohms, and its threshold is $0.1^{\circ}/\text{sec}$ or less. Operates from 115v 400 cps.—*Aeronautical Div., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

For more information circle 158 on inquiry card.

SPRING POWERED GYRO

New gyro for short-range missiles and drones has rotor energized by a spring, which brings the rotor to peak speed in a fraction of a second.



Operable instantaneously after receiving a firing signal, its simplicity is suited to low-cost high-volume applications of high reliability. Two-degree of freedom type shown supplies a potentiometer signal to control roll within $\pm 50^{\circ}$ of freedom.—*Waltham Precision Instrument Co., Waltham, Mass.*

For more information circle 159 on inquiry card.

ULTRA-MINI RF CHOKE

New micro-miniature RF choke, the WEE-DUCTOR, covers inductances from $0.10 \mu\text{h}$ to $1,000 \mu\text{h}$ in $0.150"$ by

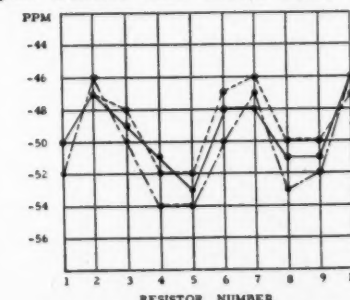


$0.375"$ long. Uses ferrite sleeve and core, moisture sealed in epoxy to MIL-C-15305A. Data on request.—*Essex Electronics, Berkeley Heights, N. J.*

For more information circle 160 on inquiry card.

HIGH STABILITY RESISTORS

Graphs shows Nat. Bur. of Standards tests on 10 Model NB-1, 10,000 ohm resistors. Solid line connects initial values, accurate within ± 4 ppm. Dashed line shows drift in 1



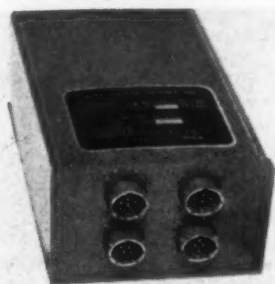
month, dot-dash line shows drift five months later. NBS Standard megohm is made up of 10 such resistors purchased in 1957 and still within 5 ppm. Catalog on precision resistors and networks on request.—*Julie Research Labs., Inc., 556 W. 186th St., New York 32, N. Y.*

For more information circle 161 on inquiry card.

MILITARY SYSTEMS DESIGN

INTEGRATING ACCELEROMETER

New transistorized integrating accelerometer provides analog outputs relative to acceleration and velocity, also closes a set of contacts at predetermined velocities from a few ft/sec to 50,000 ft/sec, in typical missile and aircraft programs. With-



stands pressures to 35 lb psia, temperatures 30° to 150°F, short shock pulses of 75 G and long shocks of 50 G, operates under 15 G vibration through 2000 cps, in available ranges from ± 1 G to ± 20 G and over. Complete technical specifications available.—*Transducer & Systems Dept., Donner Scientific Co., Concord, Calif.*

For more information circle 162 on inquiry card.

HI STABILITY CAPACITOR

New High stability Polystyrene dielectric capacitors with 0.03% to 0.01% retrace are designed for use in laboratory standards, compensat-

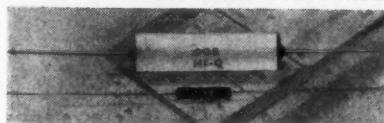


ing networks, RF filters and coupling applications. Temperature coefficient is -100 ppm/°C, ± 20 ppm, operating range is 0 to 70°C; dissipation factor at 1000 cps is 0.05%.—*Electronic Fabricators, Inc., 682 Broadway, New York 12, N. Y.*

For more information circle 163 on inquiry card.

CERAMIC MINIATURE CAPACITORS

New Cerafil capacitors, black unit here shown under white conventional

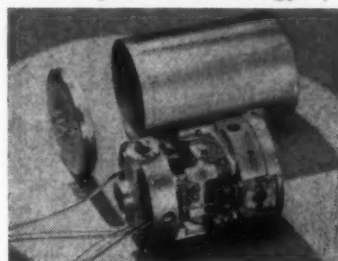


ceramic, are available in capacities from 10 μ f to 100,000 μ f in working voltages of 30 to 100 v dc. Type C80 will withstand temperatures from -55° to 125° C when derated to 50 v; meets MIL-C-11015A.—*Hi-Q Div., Aerovox Corp., Olean, N. Y.*

For more information circle 164 on inquiry card.

DUAL RATE GYRO

One RG-18 series gyro, using two gyro wheels with mutually perpendicular axes but driven from a single motor, can be used to measure both pitch and yaw. Another gyro, the

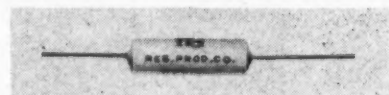


RG-20 measures two different rate ranges about the same axis to provide greater accuracy. For instance a single unit can measure the 0 to 20°/sec and also the 0 to 200°/sec ranges. Each range has a separate pickoff. The gyros meet stringent environmental conditions.—*Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.*

For more information circle 165 on inquiry card.

LOW NOISE RESISTOR

Precision Low Noise Metal Film resistor, with a temperature coefficient of ± 50 ppm/°C over a range from -65° to 165° C. Precision as-



sembly is enclosed in hermetically sealed plastic casing; is available in 500 v and 350 v max ratings, with standard tolerances of $\pm 1\%$.—*Resistance Products Co., 914 S. 13th St., Harrisburg, Pa.*

For more information circle 166 on inquiry card.

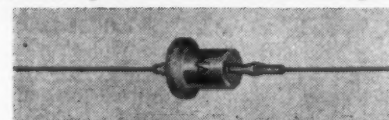
PRECISION FILM RESISTOR

New Carbon-istor, Type C $\frac{1}{2}$ C, in computer-type $\frac{1}{2}$ watt capacity is available in resistance ranges from 10 ohms to 5 meg, to $\pm 1\%$ tolerances (other tolerances available), at 350 v rating. Silver-plated end caps are expansion fitted over bands of silver paint, has negligible noise level in most applications. Meets high insulation, high temperature and moisture environment tests.—*The Kidder Co., 24 S. Springfield Rd., Clifton Heights, Pa.*

For more information circle 167 on inquiry card.

POWER RECTIFIERS

New NL line of low-cost, general purpose axial lead types provide efficient operation in ambient tempera-



tures up to 100°C. Output current rating is 500 milliamps at 100°C with PIV's from 50 to 500 volts.—*North American Electronics Inc., 212 Broad St., Lynn, Mass.*

For more information circle 168 on inquiry card.



Model 868A \$475

MAKE NO MISTAKE...

...this New Universal Bridge is DIRECT READING on all 21 ranges. Results are obtained without calculation, the balance is sharp but easily found, the design is functional. Mistakes are almost impossible with Model 868A—a bridge you will enjoy using.

21 Ranges:
 1μ H to 100H, 1μ F to 100 μ F, 0.1 Ω to 10M Ω .
 Dual Frequency, 1kc & 10kc, 400 cps to order.
 Built-in Oscillator and tuned VTVM Detector.
 Variable Bridge Voltage, meter-monitored.

BOOTHS 3314-16-18

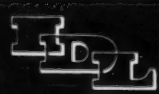
IRE
SHOW



MARCONI
INSTRUMENTS

111 CEDAR LANE • ENGLEWOOD, NEW JERSEY


For more information circle 43 on inquiry card.



ANALOG TO DIGITAL CONVERTERS

(GRAY, BINARY CODED DECIMAL)

1:1000; 1:3600; 1:216,000



For Missile and Airborne Applications

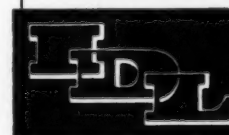
Speed and life . . . with bi-directional read-out
 8,000 bits/min for 500 hours plus 2,400 bits/min for 1000 hours
 20,000 bits/min for 300 hours plus 2,000 bits/min for 1700 hours

- Direct read-out at 20ma — 40V dc
- No brush lifting — no diodes — no networks
- Each code transfer point is unambiguously defined by a 9° least significant bit
- Passes MIL-E-5272B up to 100°C
- Ascending code—clockwise on shaft
- Synchro type mounting with pilots
- EVALUATION UNITS AVAILABLE WITHIN 30 DAYS

FOR SPECIFICATIONS SHOWN HERE, ORDER BY PART NUMBER

IDL Part Number	500206	500216	500217
Total number of bits	1000	3600 (0.1°)	216,000 (0.1')
Accuracy (Resolution)	1 bit in 1000	1 bit in 3600	1 bit in 216,000
Max/Min Torque (in. oz.)	1.5/.3	1.5/.3	3.5/.3
Bits per shaft revolution	40	40	40
Weight (incl. cables)	4.7 oz.	4.8 oz.	8 oz.
Case Length	2 $\frac{3}{8}$ in.	2 $\frac{3}{8}$ in.	2 $\frac{3}{8}$ in.
Mounting Pilot	1.754" dia.	1.754" dia.	2.156" dia.

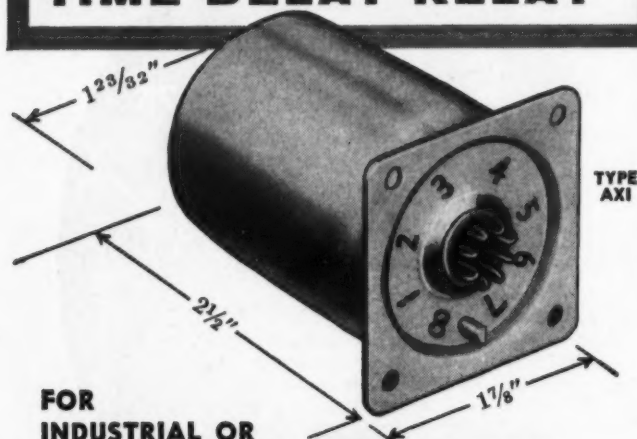
Other models available.



For prices and complete specifications write
INSTRUMENT DEVELOPMENT LABORATORIES, INC.
 Subsidiary of Royal McBee Corporation
 54 MECHANIC ST., ATTLEBORO, MASSACHUSETTS, U.S.A.

For more information circle 44 on inquiry card.

EAGLE "Mil-Spec" Precision TIME DELAY RELAY



FOR
INDUSTRIAL OR
MILITARY APPLICATIONS REQUIRING
2000 cps VIBRATION TESTS

SPECIFICATIONS

- | | |
|--|---|
| a. Operates during 5 to 2000 cps, 10G vibration. | d. D.C. operating coil. Wgt. 9 oz. |
| b. Operates -55° to +125° C. | e. Hermetically sealed. |
| c. Withstands 30G 11ms shock. | f. Timing not affected by voltage variations. |

Write for descriptive Bulletin No. 820. Address Dept. MA-259.



SIGNAL CORPORATION
Industrial Timers Division • Moline, Illinois

For more information circle 45 on inquiry card.

Insure LONGER LIFE FOR MOVING PARTS
INCREASE EFFICIENCY . . . REDUCE MAINTENANCE
WITH

SPRAY GRAPH

THE
LATEST IN
LUBRICATION!



Where oils and greases are not feasible or desirable
INSTANT DRYING—LONG LASTING
LIQUID SPRAY GRAPHITE

Dries to a long lasting solid film lubricant seconds after application to any metallic or non-metallic surface. Clean and dry, does not pick up lint, dust or dirt.

Easy to apply without drippage on even those hard-to-lubricate surfaces. Effective lubrication from 100° below zero to 800° F. Prevents sticking, reduces oxidation and corrosion.

Handy 6 oz. spray container, \$1.25 ea.
Case lots, twelve 6 oz. containers, \$11.76 per case.
Also available in bulk, \$14.90 per gallon.

F.O.B. CHICAGO, ILLINOIS

Or, send your parts to us
for special in-plant lubrication.



**AMERICAN RESIN
CORPORATION**

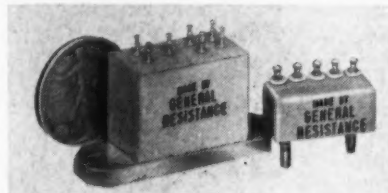
3215 NORTH SHEFFIELD CHICAGO 13, ILLINOIS

For more information circle 46 on inquiry card.

New Products—CONT.

PRECISION RESISTOR NETWORKS

High reliability resistor networks with accuracies as high as $\pm 0.005\%$ under all ambients from 0° to 70°C in new hermetically sealed line of GenRes networks. Resistance densi-

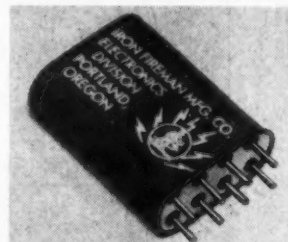


ties to as high as 4 megohms/cu-in maintain quadrature effects as low as 0.1 mv/volt input.—General Resistance Inc., 577 E. 156th St., New York 55, N. Y.

For more information circle 169 on inquiry card.

CRYSTAL CAN RELAYS

Micro-miniature relays with sensitivities as low as 25 mw (SPDT) and 40 mw (DPDT) in crystal-can case with 0.2" modular terminals meet Mil-specs requiring vibration



immunities of 20 G up to 2000 cps and shock of 100 G. Min. life is rated at 100,000 operations at 125°C with contact loads of 2 amp at 115 v rms or 28 v dc.—Electronics Div., Iron Fireman Mfg. Co., 2838 S. E. Ninth Ave., Portland, Ore.

For more information circle 170 on inquiry card.

DELAY RELAY ALWAYS READY

New relays for missile and airborne use feature instantaneous reset, temperature and voltage compensation, and high resistance to shock and vi-

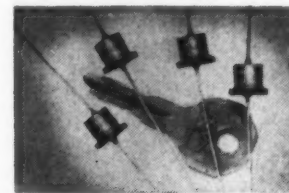


bration. Thermal and magnetic elements are combined to allow thermal delay unit to cool during time delay interval, allowing instant resetting the instant they are deenergized. Full specifications on request.—Curtiss-Wright Corp., Electronics Div., 260 Passiac Ave., E. Caldwell, N. J.

For more information circle 171 on inquiry card.

SILICON RECTIFIERS

New types 1N1763 silicon rectifier with 400 v PIV rating, and type 1N1764 with PIV rating of 500 v, both have dc load current rating of 500 ma at 25°C, and max reverse

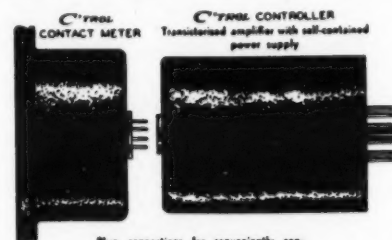


current of 100 μ amp at peak inverse voltage. New types are said to withstand high temperatures and to be usable in applications where previous silicon rectifiers were too expensive.—Tech Info. Service., Raytheon Mfg. Co., 55 Chapel St., Newton 58, Mass.

For more information circle 172 on inquiry card.

CONTACT METER CONTROLLER

Continuous control or limitation of any electrical variable is achieved by C'TROL contact meter and controller amplifier. Signal current of the order



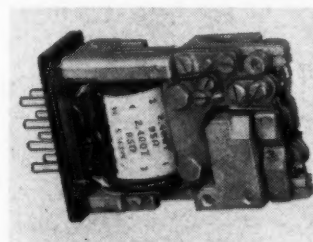
Plug connections for conveniently connecting Amplifier to Meter when mounted separately. Interconnecting cables are supplied.

of a microampere control amperes in the complete system, Modular design permits panel mounted meter to be separated from chassis-mounted controller, if desired.—Waters Manufacturing, Inc., Wayland, Mass.

For more information circle 173 on inquiry card.

POLARIZED RELAY

New Type 51 Carpenter polarized relay, in bi-stable (Type 51A) or center-stable (Type 51M) form, acts as sensitive null-sensing device without amplifiers, producing square-wave output from weak input signals.

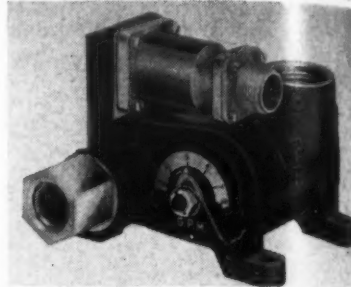


Life of 1 million accurate response cycles without readjustment is claimed. Withstands 4,000 shocks at 40 G; operates within 0.7 msec; max 20% performance change from -40° to 70°C.—C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.

For more information circle 174 on inquiry card.

CONSTANT FLOW REGULATOR

New regulator for injected water-alcohol, fuels, hydraulic and lube oil flow operates at temperatures over -65° to 250°F range. Preset flow rate is adjustable from 3 to 8 gpm,



and is maintained constant regardless of pressure differentials of 30 to 100 psi. Incorporates a filter, normally open solenoid shut-off valve, pressure relief valve, and reverse flow check valve. Can be modified for pressure differentials up to 3000 psi. Bulletin 58-123 available.—Sales Dept., Aero Supply Mfg. Co., Inc., Corry, Penna.

For more information circle 175 on inquiry card.

MISSILE SOLENOID VALVE

New in-line solenoid valve, Series V-27200, uses Teflon and stainless steel parts to handle cryogenic fluids, ethylene oxide, jet fuels, liquefied



gases and hydraulic oils over temperatures from -320° to 500°F. Variations are available for operation from 750 psi with 0.125 orifice to 4,500 psi with 0.020 orifice. Responds in 15 milliseconds.—Valcor Eng. Corp., 5370 Carnegie Ave., Kenilworth, N. J.

For more information circle 176 on inquiry card.

HIGH-PRESSURE, LOW-FLOW BLOWERS

New Series 300 centrifugal blowers give high efficiencies at extremely low flows, and provide high pressures (up to 4 psi) in very compact



units. Only 4" wide by 5 1/2" long, weight of twin blowers including 1/10 hp motor is only 2 1/2 lbs. For either 115 v 400 cps or 12/24 v dc power.—Sawyer-Bailey Corp., 1559 Niagara St., Buffalo 13, N. Y.

For more information circle 177 on inquiry card.

MILITARY SYSTEMS DESIGN

IMPORTANT ANNOUNCEMENT TO
ALL ENGINEERS—EE, ME, AE, CE:

A New Organization Now Forming at General Electric to Integrate and Direct Systems Management of Prime Defense Programs

From within General Electric, and from industry at large, talented scientists and engineers from diverse disciplines are coming together to form the nucleus of the new Defense Systems Department.

The responsibilities of this new group encompass management of theoretical and applied research as well as advanced development on major terrestrial and space-age systems.

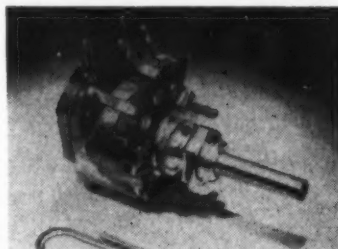
Engineers and scientists interested in exploring the broad new possibilities in the Defense Systems Department are invited to investigate current openings.

Direct your inquiry
in confidence to Mr. E. A. Smith
Section K



SMALLER-THAN-DIME POT

New Series 44 0.2 watt carbon potentiometer is intended primarily for space-saving assemblies and transistorized circuits. Measuring



only 21/32" dia. it is available in a number of resistors and tapers listed in catalog available on request.—Clarostat Mfg. Co., Inc., Dover, N. H.

For more information circle 178 on inquiry card.

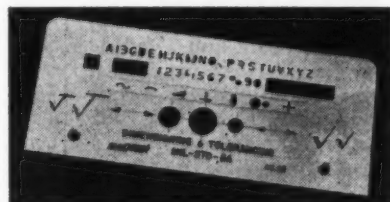
ZENER REGULATORS

Line of zener diffused junction regulator units in 1/4, 1 and 10 watt ratings range from 5.6 v through 200 v in 10% voltage steps. Technical Bulletin 30-58 with detailed data available on request.—Semiconductor Div., Hoffman Electronics Corp., 930 Pitner Ave., Evanston, Ill.

For more information circle 179 on inquiry card.

DIMENSIONING TEMPLATE

New No. 52 dimensioning and tolerancing template contains MIL-STD-8A symbols, standard rectangles

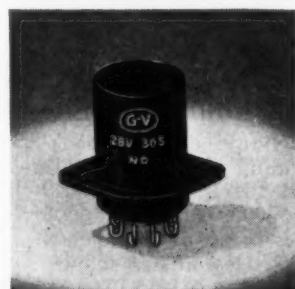


and circles, arrowheads, and 1/4" letters and numbers.—Rapidesign, Inc., P. O. Box 429, Burbank, Calif.

For more information circle 180 on inquiry card.

SUBMIN THERMAL DELAY RELAY

New hermetically sealed thermal delay relay in subminiature size uses G-V's basic principle of longitudinal expansion, operates in 20 G vibration



up to 1000 cps; 50 G 11-ms shock. Contacts are 2 amp resistive in SPST, NO or NC.—G-V Controls Inc., Okner Parkway, Livingston, N. J.

For more information circle 181 on inquiry card.

INSPECTION SCOPE

New Omniscope, having a 180° hemispheric field of view, requires no rotation, changing of heads or scanning to aim at different regions. Furnished in lengths up to 40 feet,



the depth of field extends from 1/4" to infinity. Custom-built designs, special illumination and photographic attachments can be furnished.—Lerma Engineering Corp., Box 168, Northampton, Mass.

For more information circle 182 on inquiry card.

VISUAL INSPECTION AID

Third dimension magnified vision is provided to aircraft tool inspector by binocular MAGNI-FOCUSER,



which leaves his hands free. Detailed information on MAGNI-FOCUSER on request.—Edroy Products Co., 480 Lexington Ave., New York, N. Y.

For more information circle 183 on inquiry card.

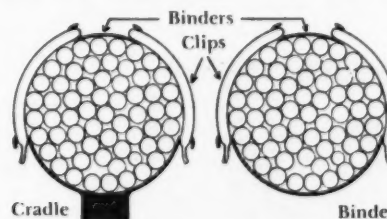
SMALLEST METAL HOSE

Heat-resistant titanium strip formed into a flexible tube with I.D. of 0.050" is available in commercial quantities for designers and engineers in nuclear instrumentations, rockets, and aircraft.—Flexonics Corp., Maywood, Ill.

For more information circle 184 on inquiry card.

CABLE SUPPORTS

New Nylon Cradles, Binders, with extensible clips of Neoprene, Silicone or Viton are available in sizes to hold cable runs from 1/8" to 2 1/4" dia

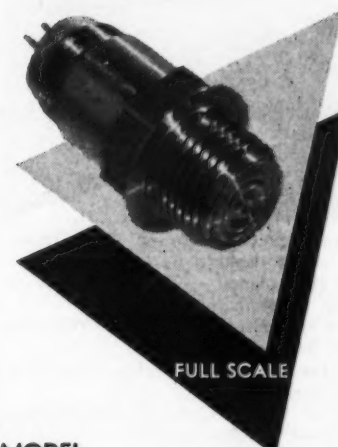


securely fastened to panels or cubicle walls. Quickly installed, "Cradle Clips" can be opened and closed as often as necessary to accommodate changes in wiring, etc. 4-page technical information bulletin #201 with installation sheets on request.—Electrovert, Inc., 124 E. 40th St., New York 16, N. Y.

For more information circle 185 on inquiry card.

Dynisco

Thermally Insulated PRESSURE TRANSDUCER



MODEL
PT 61

FULL SCALE

Incorporates
Unbonded Strain Gauge

HIGHLIGHTS

- WELDED FLUSH-MOUNTED DOUBLE DIAPHRAGM
- MAXIMUM OUTPUT TRANSIENT DUE TO SUDDEN DIAPHRAGM TEMPERATURE CHANGE OF 100°F IS LESS THAN 2% OF FULL OUTPUT
- NON-LINEARITY LESS THAN 1/2%
- MINIATURE SIZE

PRESSURE RANGES
0-250 to 0-1500 psi

REQUEST BULLETIN
NO. 5803

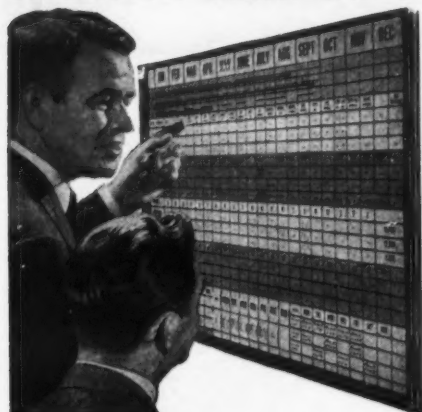
For more information on Dynisco pressure, force, flow, and displacement pickups,

write:

DYNAMIC INSTRUMENT CO.
42 Carleton Street
Cambridge 42, Mass.
UN 4-7260

For more information circle 47 on inquiry card.

You Get Things Done With Boardmaster Visual Control



- ☆ Gives Graphic Picture of Your Operations — Spotlit by Color
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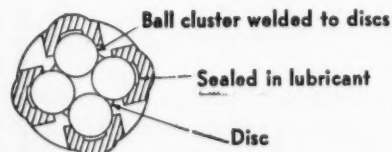
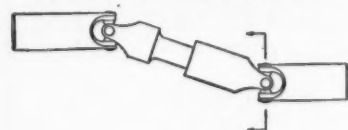
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GRAPHIC SYSTEMS

55 West 42nd Street • New York 36, N. Y.
For more information circle 48 on inquiry card.

MINI-JOINTS

Now Available With
Preloaded Ball Spline
As Telescoping Double Joint
with ZERO BACKLASH



Features

- Zero backlash • Maximum operating angle of 30° • Lightweight • Sealed-in Lubrication

SINGLE JOINT DIMENSIONS

Pt. No.	Bore	Body	Length	Torque In. Oz.	Price 1-9
SBS	Solid	3/16	1-1/32	4	\$4.35
1BS	.0938	3/16	"	"	\$4.65
2BS	.125	"	"	"	"
3BS	.156	9/32	1-3/8	16	4.55
4BS	.1875	"	"	"	"
5BS	.2188	3/8	1-3/4	64	4.50
6BS	.250	"	"	"	"

Literature available

FALCON MACHINE & TOOL CO., INC.
210 Concord Turnpike, Cambridge 40, Mass.

For more information circle 49 on inquiry card.

New Products—CONT.

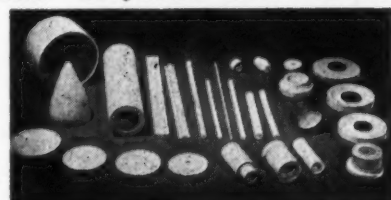
HI-TEMP FERROMAGNETICS

New Ferrotron high-temperature non-memory, inductive core materials are said to change less than 10% in Q and permeability after 100 hrs at 275°C. Useful as tuning cores, cup and loading cores, the material has positive Q coefficient, constant permeability, volume resistivity of over 10¹⁰ ohm-cm and high dielectric and impact strength.—*The Polymer Corp. of Penna., 2140 Fairmont Ave., Reading, Penna.*

For more information circle 186 on inquiry card.

HEAT SINK INSULATOR

Excellent electrical insulation up to 4600°F is combined with thermal conductivity equal to brass in new "BER-LOX" beryllium oxide extruded



shapes. Applications include pyrometer sleeves, missile nose cones, wave guide windows, heat exchangers and reactor moderators.—*National Beryllia Corp., 4501 Dell Ave., North Bergen, N. J.*

For more information circle 187 on inquiry card.

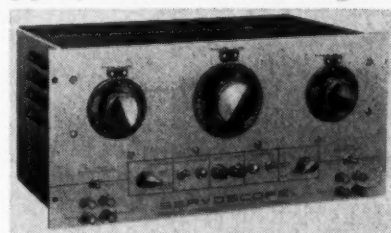
STROBOSCOPIC LAMP

New Strobex, high-intensity stroboscopic lamp and power unit is used for continuous slow-motion observation of vibrating or rotating specimens, for precision measurement of rotary or oscillatory speed, or as uniform, fast illumination in photographing high-speed objects.—2-page bulletin gives details.—*Chadwick-Helmuth Co., 472 E. Duarte Rd., Monrovia, Calif.*

For more information circle 188 on inquiry card.

SERVO SYSTEMS ANALYZER

New Model H Servoscope for analysis of servo systems measures phase, transient response and gain. It facilitates fast, accurate plotting of Nyquist, Bode or Nichols diagrams.



Frequency ranges covered are 0.1 to 2.0 cps and 1.0 to 20 cps. Frequency accuracy is ±5% of setting, rather than of full scale. Accuracy phase measurements is ±1°.—*Servo Corp. of Amer., 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.*

For more information circle 189 on inquiry card.

PRECISION COMPRESSION SPRINGS

New "Herringbone" and "Gimbal" compression springs, for control applications where conventional springs

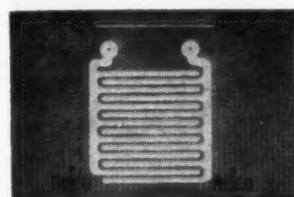


are inadequate, are machined, heat treated, and precisely ground to provide square ends, tight control of free length and exact matching of specified rate.—*Consolidated Controls Corp., Bethel, Conn.*

For more information circle 190 on inquiry card.

GLASS FABRIC LAMINATE

New NELCO 230-R glass reinforced phenolic laminate is certified to equal or exceed MIL-P-3115B, Type PBE-P



grade. Furnished in thicknesses from 0.032" to 1.000", plain or copper-clad, has unusual flexural and impact strength, low water absorption, Samples and data on request.—*New England Laminates Co., Inc., 481 Canal St., Stamford, Conn.*

For more information circle 191 on inquiry card.

SOLDER BATH DECONTAMINANT

New antidote for copper-contamination of dipping solder bath, Rowex-29, is powder that is stirred into molten solder bath (1 oz to 100 lbs solder). Forms insoluble, skimmable dross in 30 min, removing dissolved copper that makes solder dull, sluggish and brittle with an elevated melting point.—*Rowe Engravers, Lyon at E. 16th St., Paterson 4, N. J.*

For more information circle 192 on inquiry card.

SUPER-TEMP HOOKUP WIRE

Extruded polyvinyl chloride hookup wire conforming to MIL-W-16878 B (Navy) types "B", "C" AND "D" with ratings of 600, 1000 and 3000 v respectively, is being produced in a number of AWG sizes, and in insulation colors conform to MIL-STD 104. Temperature rating for continuous operation is from -55° to 105°C.—*American Super-Temperature Wires, Inc., 2 West Canal St., Winooski, Vt.*

For more information circle 193 on inquiry card.

Gain of Parabolic Antennas

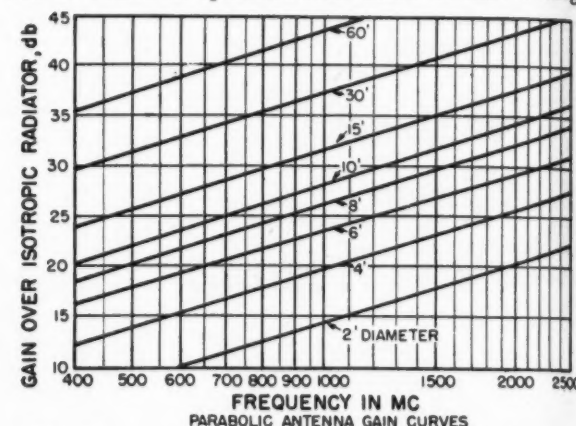
The gain of a parabolic antenna may be expressed as

$$G = 10 \log_{10} 4\pi Ag/\lambda^2$$

in db over an isotropic radiator, where A is the projected area of the reflector, g is the gain factor or efficiency of the antenna, and λ is the wavelength corresponding to the operating frequency.

Gain factor depends on such parameters as aperture illumination taper, spill-over energy, reflector tolerance, and particularly the separation of the phase center of the feed in the E and H-planes. The gain factor of most antennas is about 55%.

The curves below represent the theoretical gain of popular sizes of parabolic antennas, based on an efficiency of 55%. To convert to gain over a dipole, subtract 2.15 db. Guaranteed gain of Andrew antennas will be found in specifications listed in this catalog.



Ideally, a parabolic antenna requires a point source at its focal point as a feed. A practical feed will give certain phase error across the aperture with resultant gain reduction. This error may be measured in terms of separation of feed phase centers in E and H-planes. An electromagnetic horn has phase centers with least known separation. Thus, it gives the least aperture error and is most suitable for a parabolic antenna feed. In addition, illumination intensity at the edge of the parabolic antenna may be controlled by properly proportioning the horn.—(From engineering data section of 105-page Catalog No. 22, Andrew Corporation, 363 E. 75th St., Chicago, Ill.)

For this literature circle 194 on inquiry card.

Jet Instrument Design Aided by Precise Tape Splicing

VERTICAL-SCALE design of new jet aircraft instruments pioneered by Bendix' Eclipse-Pioneer Division in conjunction with the Wright Air Development Center employs moving tapes in two vertically mounted instruments that tell a pilot at a single glance what is happening and what needs to be done (Fig. 1). Because the instruments are easily interpreted and compactly packaged, the system provides a visual indication that can be scanned with a single horizontal motion of the pilot's eyes. This system shortens pilot training time, requires less panel space and requires fewer components.

The instrument design uses two endless nylon-covered fiber-glass tapes, one inside the other. Numer-

MILITARY SYSTEMS DESIGN

als are sandwiched under tough transparent nylon surfaces for protection from wear. These tapes, developed by the General Plastics Corp., Paterson, N. J., are light, flexible, yet highly durable.

The inner tape is longer than the outer by several sprocket holes. These tapes, driven by individual sprockets, run over idlers while in the viewing area. The inner tape bears numerals which appear in the windows of the outer tape, which is graduated. The difference in length between the tapes, combined with the numeral sequence, causes an indexing action which is not seen by the pilot.

An unusual degree of precision was required in the splicing of the belts, as any slight deviation during the splicing operation from the prescribed length would

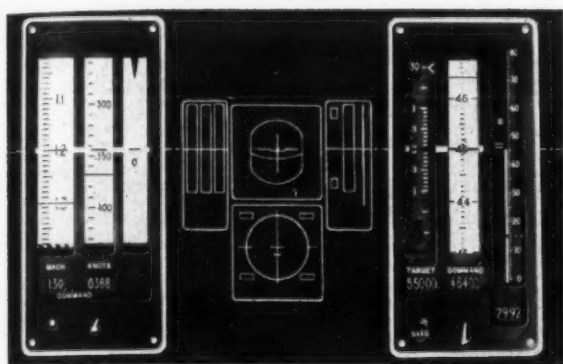


FIG. 1.

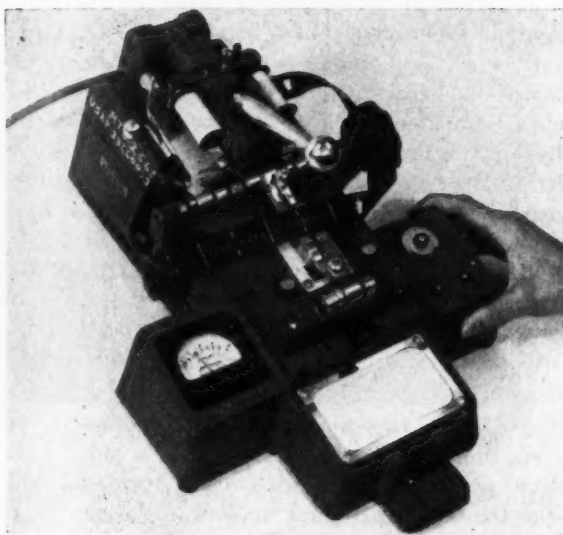


FIG. 2.

cause inaccurate readings. A method was needed that would uniformly (1) cut at an exact spot on the tape, (2) seal the ends in precise lateral alignment, (3) produce minimum ridge at the splice, and (4) meet rigid length tolerances. In this case, the Prestoseal Manufacturing Corporation, Long Island City, N. Y., working closely with the tape and instrument manufacturers, adapted their standard Presto-Splicer to form a 0.040" overlap splice which was compressed flat on the sprocket drive side and squeezed to within 0.001" of the thickness of a single layer of tape (Fig. 2). The splice, completed in 2 3/4 seconds by application and temperature, is stronger than any other spot on the tape.

For more information on Presto Splicer circle 195 on inquiry card.

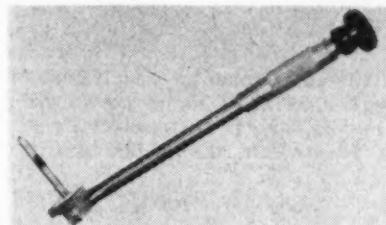
SCOPE DOLLIES

New dollies embody refinements and conveniences demanded by users, such as 3" rubber-tired ball-bearing swivel casters.—*Technical Service Corp., 1404 Market St., Louisville 3, Ky.*

For more information circle 196 on inquiry card.

INSPECTION SCOPE

New type borescope is provided with swivel joints for convenient eyepiece location, feature 4 1/2x magnification in a 3/8" ID bore and individual



focusing of eyepieces. Inspects bolt holes in interior of aircraft wings, interior of jet engines, etc.—*Lenox Instrument Co., 2010 Chancellor St., Philadelphia 3, Pa.*

For more information circle 197 on inquiry card.

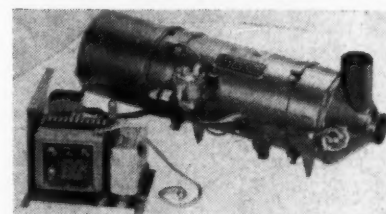
SPACE, WEIGHT SAVED BY NEW CABLE

New fused film Teflon miniature multiconductor cables for aircraft and missiles pack 56 #22 wires/sq-in compared to 37 wires in conventional cables. Up to 250 lbs per aircraft saved in weight. Available in continuous unsliced pinhole-free lengths to 1000 ft, in gauges from #28 through #18 AWG, in construction of 1 to 4 conductors, shielded.—*Inso Products, Ltd., Div. of Adams Consolidated Industries, 404 Fifth Ave., New York 18, N. Y.*

For more information circle 198 on inquiry card.

WINTERIZING HEATER SYSTEM

Model UH-86 heavy duty engine heater supplies high-temperature, high volume air for starting internal combustion engines in frigid military



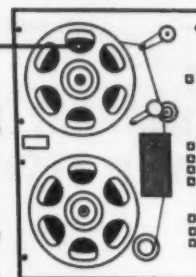
ground support applications. Burns any grade of gasoline or JP-4 fuel, starts with spark ignition under extreme conditions, is being used for winterization gear on the PE-150 engine, prime mover for the MD-3. Supplies 110 cfm air at 3.5" pressure with 450°-500°F temperature rise.—*Hunter Mfg. Co., 30525 Aurora Rd., Solon, Ohio.*

For more information circle 199 on inquiry card.

RAPID ACCESS

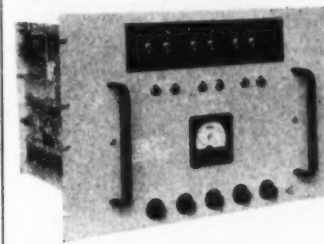
IN ANALOG DATA REDUCTION SYSTEMS

Three companion units by Hycon Eastern provide automatic indexing and high-speed access to selected data in multi-channel magnetic tape instrumentation systems.

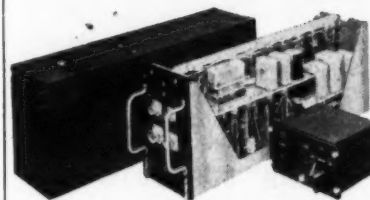


For Tape Indexing

DIGITAL TIMING GENERATOR, MODEL 201, generates numerically coded timing signals which are recorded on magnetic tape throughout the data recording periods, providing a precise digital index in terms of elapsed time. The Generator also visually displays the exact time in hours, minutes and seconds as illuminated digits.



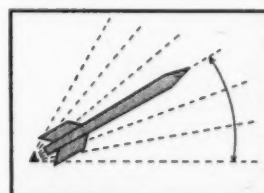
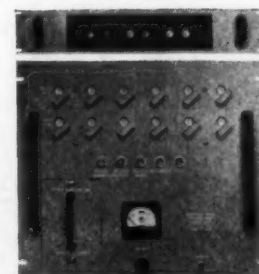
DIGITAL TIMING GENERATOR, MODEL 206A, FOR AIRBORNE APPLICATIONS is a militarized version of Model 201. A Remote Control Box contains Power off-Standby-Operate Switch, the Digital Clock Set, and the Time Display. Completely transistorized, Model 206A includes a binary coded decimal system al-



though other timing formats are available to meet customer requirements, Weighing only 15 pounds, Model 206A is stable to 1 part in 100,000 giving an accuracy of ± 1 second in 1 day's time.

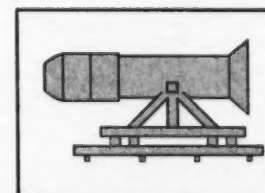
For Tape Search

MAGNETIC TAPE SEARCH UNIT, MODEL 202, operates during data reduction periods. On the basis of time indices recorded on the tape by the Digital Timing Generator, this instrument automatically locates and selects for controlled playback the tape data included between a "sequence start time" and a "sequence end time" specified by panel dial settings. The time index is visually displayed as illuminated digits on a small separate panel which may be remotely located for convenience. Model 202 may be modified to search for timing formats other than those originated by Model 201.



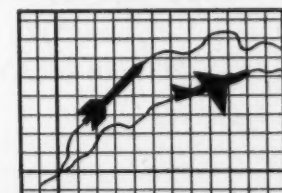
WIND TUNNEL TESTING

Pressure and temperature data of missiles are referenced to angle of attack. Model 201 records on tape a digitized position signal for each new angle of attack.



JET ENGINE TESTING

Digital Timing Generator, Model 201 synchronizes all data receiving equipment. Its output can be piped to multiple test cells and control rooms simultaneously.



MISSILE AND AIRCRAFT TESTING

Model 206A generates timing signals simultaneously with other flight test data. Model 201 generates a timing code format for synchronizing ground station recordings.

Write for Technical Bulletin TSG



HYCON EASTERN, INC.

75 Cambridge Parkway, Dept. U, Cambridge 42, Mass.

For more information circle 50 on inquiry card.

DISPLAY DEVICES AND TECHNIQUES

Several unusual openings for Electrical Engineers with 3 to 5 years' advanced engineering experience and the ability and initiative to make individual contributions. These engineers will work on research programs leading to advanced developments in:

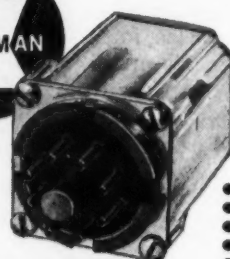
Display devices for airborne weapons systems — flight control, fire control, IR, radar and CIC — CRT circuits, computer read-in and read-out and solid state, color and 3-D display techniques.

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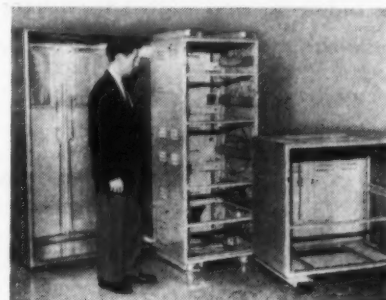


For more information circle 51 on inquiry card.

New Products—CONT.

MIL-SPEC CABINETS

New lightweight aluminum alloy cabinets complying with MIL-T-17113 are custom-built from standard stock

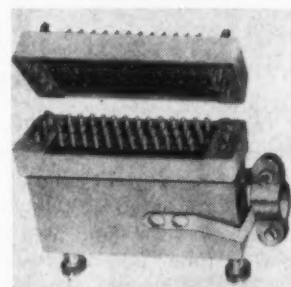


parts for delivery in 30 days. Feature built-in cooling ducts, protected harness ways, shock mounts as required, and size and load capacity to meet customer's needs.—Aircraft Armaments, Inc., Cockeysville, Md.

For more information circle 200 on inquiry card.

"NO STRAIN" CONNECTOR

Miniature bracket-type screw lock connectors, designated FBI series, use patented Floating Body Isolation,

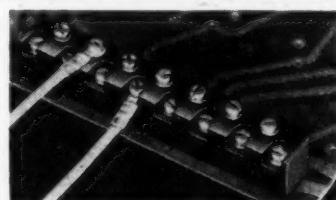


which means that stresses and strains are taken up by the frame and are not transmitted to the connector bodies of insulating material supported within the frame.—U. S. Components, Inc., 454 E. 148th St., New York 55, N. Y.

For more information circle 201 on inquiry card.

PRINTED CIRCUIT TERMINAL BLOCK

New miniature terminal block that mounts on PC boards, designated Type 520, eliminates soldering by



providing screw connections integral with terminal pins that slip into standard connector mounting holes in the PC board, where they are dip-soldered.—Kulka Electric Corp., 633-643 S. Fulton Ave., Mount Vernon, N. Y.

For more information circle 202 on inquiry card.

SERVO GEAR HEADS

New Size 11 Precision Gear Heads for use with BuOrd size 11 servo-motors are designed for high and low temperature applications and

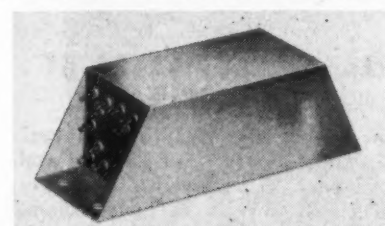


meet all environmental requirements of MIL-E-5272A. Adapt also other size motors.—FAE Instrument Corp., 42-61 Hunter St., Long Island City 1, N. Y.

For more information circle 203 on inquiry card.

SERVO MAG AMPLIFIER

Compact magnetic amplifier provides push-pull dc outlet for standard hydraulic transfer valves used in missile and aircraft control. Also is



used in missile autopilot manufactured by Vickers, Inc. Input range is from -1v to +1v, maximum output is +15 ma and +15 v; gain is externally adjusted; uses supply of 115v, 2400 cps.—Electric Products Div., Vickers Inc., 1815 Locust St., St. Louis 3, Mo.

For more information circle 204 on inquiry card.

MINIATURE AUDIO AMPS

Transistorized audio amplifiers using military approved components and designed for incorporation in military receivers are available in stock



types from 120 mw to 2.0 watts output, and having audio gains of 45 db to 66 db. Units to meet special input and output impedance requirements may be furnished with power outputs to 20 watts. Encapsulated units are hermetically sealed, plug into a standard 7-pin socket.—Ferrotran Electronics Co., 693 Broadway, New York 12, N. Y.

For more information circle 205 on inquiry card.

Operation of Transistorized Servo Power Amplifier

Power Amplifier Models SC-AU20-001/-002 are universal carrier-type amplifiers requiring a 60 cps signal voltage of the same phase as the supply voltage (Fig. 1). Designed with zero-drift, wide bandwidth, and isolated input circuits for driving ac servo motors and dc torque motors rated at up to 5 watts output, they also provide for command feed-back input signal summation, comparison, or difference in a wide range of electrohydraulic servo system applications.

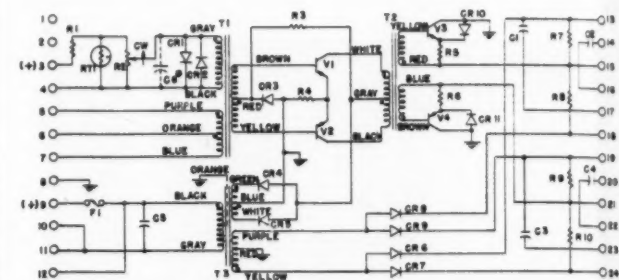


FIG. 1. TRANSISTORIZED Servo Amplifier is designed to drive ac servo, dc torque motors and electrohydraulic actuators.

Assume that an "in phase" AC signal is applied to input terminals 3 and 4 and that the instantaneous polarity is positive at terminal 3 during the first half cycle as indicated by the (+) sign. The line reference voltage at terminal 9 is simultaneously positive. Consideration of the instantaneous polarities existing through the first stage shows that the base of power transistor V3 will be instantaneously driven negative during this half cycle which is the necessary condition for conduction of the PNP power transistor V3. The base of power transistor V4 is simultaneously driven positive and V4 will not conduct during the first half cycle.

Thus, in the first half cycle current flows through the rectifier (CR6), the resistor (R7), the 15 ohm emitter resistor (R5), and through transistor (V3) due to the negative voltage applied to the base of V3. During the second half cycle of the input signal, current flows through rectifier (CR9), the resistor (R9), the other emitter resistor (R6), and the transistor (V4) which now conducts while the other (V3) is cut off by a positive base voltage during the period of the negative half cycle.

Thus, for an "in phase" signal, positive voltage appears across output terminals 13 and 15 during the first half cycle and across terminals 19 and 21 during the second half of the cycle.

For input signals of opposite or "out of phase" instantaneous polarity, positive voltage will appear across output terminals 18 and 15 during first half cycle and terminals 24 and 21 during the second half of the cycle.

For zero input signal, approximately equal small voltages appear across the resistors (R7, R8, R9 and

R10) or terminal pairs (13 & 15), (18 & 15), (19 & 21) and (24 & 21) respectively.—(From 4-page Technical Bulletin 36200, Servocontrol Division, The Oilgear Company, Milwaukee 4, Wisc.)

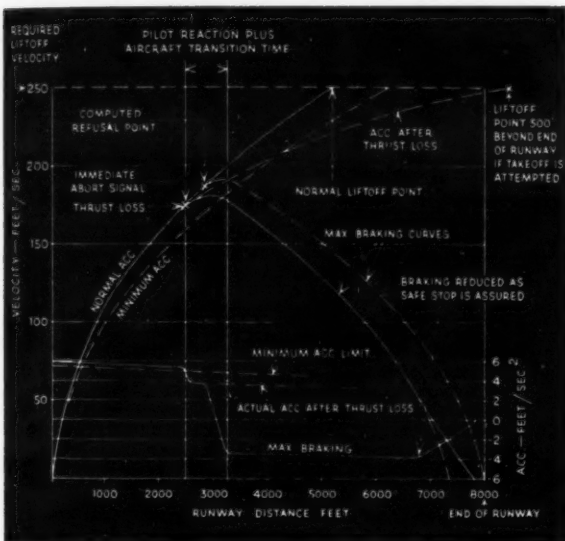
For this literature circle 206 on inquiry card.

Takeoff Monitor Aids Jet Pilot

Transition to jet aircraft has removed the usual kinesthetic and noise references which formerly enabled the pilot to monitor the takeoff performance of his aircraft. High performance aircraft require complete pilot attention to takeoff requirements allowing only limited time for reference to engine performance indicating systems, position on runway, etc.

The Honeywell Takeoff Monitor System, developed to monitor aircraft performance during the takeoff roll, presents the pilot with the information he needs to safely operate during this critical phase of the flight.

Aircraft acceleration is the parameter used to monitor aircraft performance because it instantaneously reflects any change in the aircraft thrust and drag system, allowing any deterioration to instantly trans-

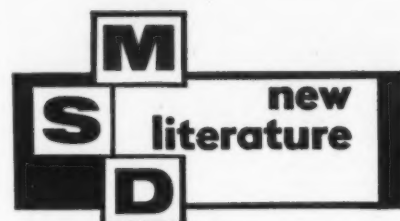


late into an unambiguous abort signal (see illustration). Any monitor system based on velocity, the integral of acceleration, would have a delay in detecting performance deterioration.

In addition, the Monitor System measures the distance traveled, providing information on distance measured to the Refusal Point. A distance circuit interlock prevents premature abort signals or abort signals from occurring after the aircraft has passed the Refusal Point.

The Monitor System consists of a control panel and an indicator panel, both located in the cockpit; an analog computer unit, containing most of the electronic components of the system; a pitch attitude sensor on the landing gear, an odometer on the aircraft wheel, and an accelerometer in the aircraft structure. Designs are available for civil as well as military type aircraft.—(From 8-page brochure, Aeronautical Division, Minneapolis-Honeywell Regulator Co., 2600 Ridgeway Rd., Minneapolis 13, Minn.)

For this literature circle 207 on inquiry card.



ASTRONAUTICAL TERMS are defined in free 133-word pocket glossary, "Space Talk"—Republic Aviation Corp., Farmingdale, L. I., N. Y.

Circle 208 on inquiry card.

ANTENNA PATTERN ANALYZER for use over the 1 mc to 10 kmc range is described with specifications in new 2-page bulletin 141.—Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

Circle 209 on inquiry card.

BORESIGHT CAMERA techniques for measuring tracking error in radar antennas, or for documentation of radar tests, are explained in new Vol. 1, No. 3, Flight Research Recorder.—Flight Research Inc., Box 1-F, Richmond 1, Va.

Circle 210 on inquiry card.

DATA PROCESSING and computation facilities available for engineering and operations data analysis for military programs is described in new 17-page facilities brochure.—Missile & Space Vehicle Dept., General Electric Co., Room 6A, 3198 Chestnut St., Philadelphia 4, Pa.

Circle 211 on inquiry card.

FM DEVIATION METER and associated tuning units and calibrator are described in set of two-page data sheets, AR-1B, ATN-18, ATN-24, ATN-52, and AMD-1.—A. R. F. Products, Inc., 7627 Lake St., River Forest, Ill.

Circle 212 on inquiry card.

SUBMINIATURE Long-Scale 180° arc-scale meters meeting MIL-M-10304A requirements are described in new 4-page folder, "Ruggedized Meters."—The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.

Circle 213 on inquiry card.

MICROWAVE MEASUREMENTS, diagrams and techniques of standards measurement are given in 36-page booklet, "Microwave Standards Prospectus," Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Circle 214 on inquiry card.

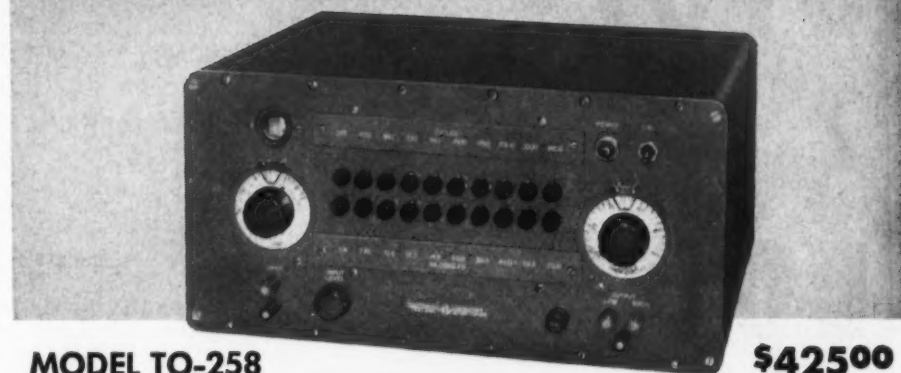
RADIO FREQUENCY METER covering 125 kc to 1,000 mc with 0.005% accuracy is described in new 4-page Bulletin DW-102.—Divco-Wayne Electronics, 9701-C Reading Road, Cincinnati 15, Ohio.

Circle 215 on inquiry card.

NAVIGATIONAL COMPUTERS for aircraft with Doppler or TAGAN tie-in are operationally described in new 14-page booklet. Clifton Precision Products Co., Inc., 9014 W. Chester Pike, Upper Darby, Pa.

Circle 216 on inquiry card.

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TELETRONICS LABORATORY, INC.

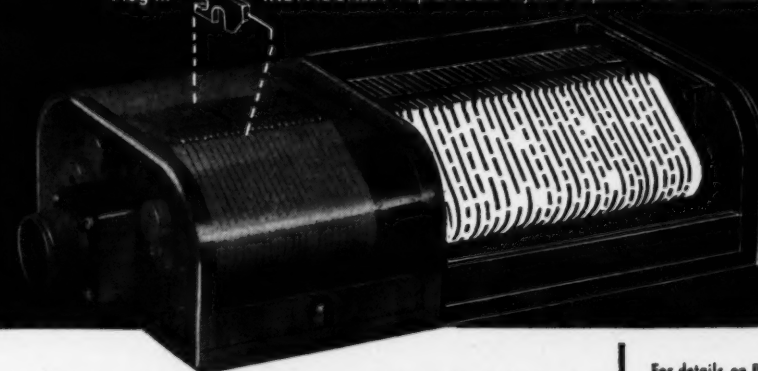
54 KINKEL STREET WESTBURY, L. I., N. Y.

For more information circle 52 on inquiry card.



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For details on Photron Oscillographs and Amplifiers, request Bulletin 210.



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For more information circle 53 on inquiry card.

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New Literature—CONT.

TELEMETERING SYSTEMS and guided missile test equipment are described in new facilities booklet and separate equipment bulletins.—Hoover Electronics Co., Timonium, Md.
Circle 217 on inquiry card.

OPEN LOOP OPERATIONAL Amplifiers having differential inputs and outputs for a wide selection of circuit applications are described in 130 Series bulletin.—Burr-Brown Research Corp., Box 6444, Tucson, Ariz.
Circle 218 on inquiry card.

TRANSISTOR-MAGNETIC servo amplifiers with power ratings to 16 watts are described in new 4-page brochure, bulletin S-893.—Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.
Circle 219 on inquiry card.

SAMPLING SWITCHES and commutators for multichannel instrumentation, both mechanical and electronic designs are discussed in new 16-page brochure by John F. Brinster.—General Devices, Inc., Princeton, N. J.
Circle 220 on inquiry card.

PRECISION SEALED SWITCHES, eight new precision snap-action types for high-temperature and shock-resistant missile, aircraft and ground-handling applications, are described in data sheet #151.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.
Circle 221 on inquiry card.

MULTIPLEXING SWITCHES using platinum-iridium, gold-nickel, phosphor bronze, chromium and rhodium materials in new low-wear designs are featured in new 6-page brochure.—Lind Corporation, Research Park, Princeton, N. J.
Circle 222 on inquiry card.

DYNAMOTORS, indicators, transmitters, warning units and synchros for aircraft and missile applications are described with design data in new 110-page Product Brochure.—Montrose Div., Bendix Aviation Corp., So. Montrose, Pa.
Circle 223 on inquiry card.

PRECISION CAMS, couplings, synchros, mechanical differentials and servo motors are described in new 4-page brochure.—Ford Inst. Co., 31-10 Thomson Ave., Long Island City 1, N. Y.
Circle 224 on inquiry card.

ADJUSTABLE-SPEED Drives, including basic methods for operating dc motors from ac sources, are discussed in 16-page catalog, #11058.—Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J.
Circle 225 on inquiry card.

SERVO MOTOR engineering data on 10 types in sizes from 8 to 18 are available in data file TWX 293.—Servo Dynamics Corp., Somersworth, N. H.
Circle 226 on inquiry card.

RELAYS, hermetically sealed telephone and power contactor types are included in 13-page engineering sketch book on fine quality relays.—Standard Electromagnetics, Inc., 43-45 S. Carroll St., Frederick, Md.
Circle 227 on inquiry card.

ACCELEROMETERS for dynamic test, including high-temperature types are listed and described in 8-page catalog, "Dynamic Test Equipment."—Columbia Research Labs., Bullens Lane & MacDade Blvd., Woodlyn, Pa.
Circle 228 on inquiry card.

PULSE TRANSFORMER theory, measurements, manufacturing and application are treated in new 24-page catalog.—PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif.
Circle 229 on inquiry card.

SILICON SOLAR CELLS with outputs up to 9 watts/sq ft area are described in Bulletin SR-275.—Astro-Power Div., International Rectifier Corp., El Segundo, Calif.
Circle 230 on inquiry card.

SILICON ZENER voltage regulator diodes are listed by ratings and typical characteristics in new 2-page Bulletin SFC 11 & 12.—International Rectifier Corp., El Segundo, Calif.
Circle 231 on inquiry card.

LOW-NOISE SILICON transistors for both low and high-impedance instrument transducers are described in new bulletin TE-1353.—Transitron Electronic Corp., Wakefield, Mass.
Circle 232 on inquiry card.

DUOTRIODE PULSE TUBE, CBS 6955; characteristics of miniature twin triode suited for blocking oscillators, square wave modulators, etc. are given in Bulletin E-274.—CBS-Hytron Adv. Service, Parker St., Newburyport, Mass.
Circle 233 on inquiry card.

FIXED FILM RESISTOR derating curves for commercial types in all standard values are given in new 2-page engineering bulletin CF-1.—Mepco, Inc., Morristown, N. J.
Circle 234 on inquiry card.

PRINTED CIRCUIT TEST point connectors are described in 6-page brochure.—Dejur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.
Circle 235 on inquiry card.

PRINTED CIRCUIT soldering by Flow-solder method is described in 2-page brochure.—Electrovert, Inc., 124 E. 40th St., New York 17, N. Y.
Circle 236 on inquiry card.

THIN-SECTION BEARINGS are compared with conventional types in new 24-page catalog and applications booklet.—Split Ballbearing Div. of MPB, Inc., Lebanon, N. H.
Circle 237 on inquiry card.

DC-DC CONVERTER inverters for missile and portable military power are described in 4-page Transidyne data file No. 701.—Spectrol Electronics Corp., 1704 So. Del Mar Ave., San Gabriel, Calif.
Circle 238 on inquiry card.

CENTRALIZED CONTROL and Data Presentation Systems; facilities for design and custom production are described in new 16-page Bulletin 106.—Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill.
Circle 239 on inquiry card.

WIRE AND CABLES to MIL-W-76A and MIL-W-16878-B (Navy) and RG type coaxial cable types are illustrated in new 6-page brochure.—National Wire and Cable Corp., 136 San Fernando Rd., Los Angeles 31, Calif.
Circle 240 on inquiry card.

CABINET COOLING fans and blowers in new models are shown in new 36-page catalog.—McLean Engineering Labs., Princeton, N. J.
Circle 241 on inquiry card.

CABINET HANDLES of vinyl-coated aluminum meeting MIL-Specs are described in 2-page data sheet.—National Radiac, Inc., 479 Washington St., Newark 2, N. J.
Circle 242 on inquiry card.

INSTRUMENT CASE details and dimensions are given in new 20-page design manual No. 401G.—TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif.
Circle 243 on inquiry card.

SILICONES in Missile Design, is title of new 6-page brochure.—Dow Corning Corp., Midland, Mich.
Circle 244 on inquiry card.

BERYLLIUM MACHINING and fabrication facilities for custom production and development are described in new 3-page folder.—Leemath, Inc., Oak Drive, Syosset, L. I., N. Y.
Circle 245 on inquiry card.

DEMAND PUMP powered by pneumatic or hydraulic pressure sources for pressurization of electronic equipment or hydraulic reservoirs, and hydraulic system leakage return is described in new data sheet WF1642.—Waldorf Fluid Systems, Waldorf Inst. Co., Wolf Hill Rd., Huntington Station, L. I., N. Y.
Circle 246 on inquiry card.

CRYOGENIC PUMPS for LOX and other liquefied atmospheric gases are described in new 4-page folder.—Linde Co. Div., Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y.
Circle 247 on inquiry card.

METAL-TEFLON HOSE for high temperature fuel and lube oil systems, missile fuel and oxidizer lines, etc., are specified in 6-page folder "Springfield 400".—Titeflex, Inc., Hender St., Springfield 4, Mass.
Circle 248 on inquiry card.

MILITARY SYSTEMS DESIGN